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Use of Biofertilizer for Increasing Soil Health and Sustainable Agriculture Production

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Abstract

When applied to seed, soil, or living plants, a biofertilizer consists of a carrier media rich in live microorganisms that boosts soil nutrients or makes them biologically accessible. The use of biofertilizers in the production system can provide improved productivity on a long term basis. As they thrive in the soil, they form a mutually beneficial or symbiotic connection with host plants. The role of several microorganism strains in crop production and improvement. Soil researchers currently view mycorrhiza fungi and plant growth-promoting rhizobacteria as microorganisms that play critical roles in nutrient availability in the soil to improve plant development and productivity. Microbial biofertilizers are helpful microorganisms that interact with the rhizosphere of plants to improve soil fertility and stimulate nutrient uptake to increase yield. The existing use of chemical fertilizers has resulted in environmental contamination and increased the expense of agricultural operations, indicating that biofertilizer research has a bright future.

Introduction

The world populations growing with high rate are reaching over 9 billion by 2050. To maintain food security, it is consequently important to drastically boost agricultural production by regulating the rhizosphere in a relatively short time frame. This has been accomplished by providing plants with the necessary nutrients, such as phosphorus (P), nitrogen (N), and potassium (K). NPK fertilizers are used to supplement the number of nutrients required for plant growth and yield performance in about 53 billion tonnes per year. Furthermore, the excessive and incorrect use of chemical fertilizers causes environmental difficulties that are a major concern for farmers, bolstering the case for the adoption of environmentally friendly agricultural practices. Siderophore production, nitrogen fixation, lytic acid generation, hydrogen cyanide production, phosphate solubilization, and indole acetic acid production are among them. Many strains of beneficial soil microorganisms have been discovered for their potential in rhizosphere management to promote plant yield (Reed *et al*., 2013), and are now being employed in biotechnology to improve food security and agricultural sustainability. Soil researchers currently view mycorrhiza fungi and plant growth-promoting rhizobacteria (PGPR) as microorganisms that play critical roles in nutrient availability in the soil to improve plant development and productivity. Microbial biofertilizers are helpful microorganisms that interact with the rhizosphere or endosphere of plants to improve soil fertility and stimulate nutrient uptake to increase yield. The use of biofertilizers minimizes the high cost of chemical fertilizers while also meeting the global demand for green technology in crop production (Mahanty *et al*., 2017).

Fungi, root bacteria, and other microorganisms are found in biofertilizers. As they thrive in the soil, they form a mutually beneficial or symbiotic connection with host plants. The roles of several microorganism strains in crop production improvement were decreased. They can be divided into following categories based on their nature and mode of action (Table 1).

Table 1: Categories of Biofertilizers in Microorganisms Used the Production food crops

Sl. No.	Biofertilizers	Groups	Microorganism
1.	Nitrogen fixing microbes	Symbiotic	*Rhizobium* sp.
		Non-Symbiotic	*Azotobacter* sp., *Azospirillum* sp.
2.	Phosphate solubilizing microbes	-	*Bacillis* sp., *Pseudomonas* sp., *Azospirillus* sp., *Micrococcus* sp.
3.	Potassium solubilizing microbes	-	*Acidothiobacillus* sp., *Burkholderia* sp., *Pseudomonas* sp.
4.	Zinc solubilizing microbes	-	*Thiobacillus thioxidans*, *Bacillus aryabhattai*
5.	Sulphur oxidizing microbes	-	*Xanthobacter* sp., *Alcaligenes* sp., *Bacillus* sp.
6.	Biocontrol microbes	-	*Bacillus subtilis*, *Pseudomonas aurofaciens*, *Pseudomonas fluorescence*, *Agrobacterium* sp.
7.	Phosphate mobilizing microbes	Mycorrhiza fungi	*Glomus intraradices*, *G. mosseae*, *Glomus deserticola*

1. Nitrogen Fixing Bacteria

They are divided into three subgroups once more.

a) Symbiotic

Bacteria in the soil *Rhizobium* spp. colonises the roots of legume plants in a symbiotic relationship, fixing nitrogen from the atmosphere to the soil, where the host plant provides shelter for the bacteria and the bacteria provides critical nitrites to the host plant. With the help of the symbiotic algae Anabaena, the water fern (*Azolla* spp.) also fixes nitrogen. Trees and Frankia have a symbiotic interaction. Clostridium, Nostoc, and other symbiotic nitrogen fixers are examples.

b) Free-living Nitrogen Fixers

Slime is produced by *Azotobacter* spp., which aids in the aggregation of soil particles.

c) Associative Symbiotic

Azospirillum spp. is present in *Graminae* spp. root cortex and has an associative symbiotic relationship with the host plant. In both aerobic and anaerobic settings, these gram negative bacteria fix nitrogen and multiply. Apart from N_2 fixation, *Azospirillum* spp. inoculation confers drought tolerance and disease resistance to the host plant. Acetobaceter is a sacharophillic bacteria that fixes 30 kg of nitrogen per hectare per year in sugarcane, sweet potato, and sweet sorghum plants. This bacteria is mostly used in the sugarcane industry. It has been shown to boost sugarcane yield by 10-20 t/acre and sugar content by 10-15%.

2. Phosphorus Solubilizers and Mobilizers

Bacteria and fungi are both crucial in soil phosphorus mobilisation. Pseudomonas striata secretes an acid that lowers the pH of soils and aids in the breakdown of phosphates that are bound in the soil. *Bacillus megaterium* var. *phosphaticum*, *Bacillus circulans*, *Penicillium* spp., *Aspergillus awamori*, and other fungi are among the bacteria that aid to solubilize phosphorus. *Arbuscular mycorrhiza* is a fungus-root symbiotic relationship that aids in phosphorus mobilisation in the rhizosphere. *Glomus* spp., *Gigaspora* spp., *Acaulospora* spp., *Scutellospora* spp., *Sclerocystis* spp., *Laccaria* spp., *Pisolithus* spp., *Boletus* spp., *Amanita*, and *Rhizoctonia solani* are some of the most important Arbuscular Mycorrhizal fungi.

3. Potassium Mobilizing Bacteria

Frateuria aurentia, free-living bacteria in the rhizosphere, is critical for soil potassium mobilisation. *Bacillus spp.* it was discovered that a substance isolated from the soil of a granite crusher yard may solubilize silica and potassium, as well as increase rice yield. Plant growth promoting rhizobacteria, or PGPR, are beneficial free-living soil bacteria isolated from the rhizosphere of plants that have been found to benefit plant health and yield (Kloepper *et al*., 1980). Bioprotectants, biofertilizers, and biostimulants are all examples of PGPR. Few PGPR may aid in the development of fine roots, hence increasing the absorptive area of plant roots, which improves water and nutrient uptake. Plant hormones such as indole acetic acid (IAA), gibberellins, and cytokinins are also produced by PGPR.

Different Types of Biofertilizers

a) Rhizobium

This bacteria infect the legume root and create root nodules, where they convert molecular nitrogen to ammonia, which the plant uses to make important proteins, vitamins, and other nitrogen-containing substances. Different legume crops are expected to fix 40-250 kg N/ha/ year through the microbial activity of *Rhizobium* spp.

b) Azotobacter

It is applied to all non-leguminous plants, such as rice, cotton, and vegetables. The azotobacter cells can be found on the rhizosplane and in large numbers in the rhizosphere. The absence of organic matter in the soil is a limiting factor for azotobaceter multiplication.

c) Cyanobacteria

A collection of aquatic organisms with one to many cells. Blue green algae is the most common name for this category (BGA). For rice crops, both symbiotic and free-living BGA are advantageous.

d) Azospirillum

Non-leguminous plants such as grains, millets, oilseeds, and cotton are known to fix a significant amount of nitrogen in the rhizosphere, ranging from 20 to 40 kg N/ha.

e) Azolla

Azolla is a free-floating water fern that fixes atmospheric nitrogen in collaboration with the nitrogen-fixing blue green alga "*Anabaena azollae*." Azolla fronds are made up of a sporophyte with a floating rhizome and little bi-lobed leaves and roots that overlap. In terms of nitrogen contribution to rice, Azolla is seen to be a viable biofertilizer. Azolla has long been used as a food for domesticated animals such as pigs and ducks, prior to its development as a green manure. Azolla is increasingly being used as a sustainable feed supplement for animals, particularly dairy cattle, poultry, pigs, and fish.

f) Phosphate Solubilizing Microorganisms (PSM)

Bacillus megaterium var. *phosphaticum* and *Bacillus circulans* are members of this group. *Aspergillus awamori* spp., *Penicillium* sp.

g) Arbuscular Mycorrhiza

The fungus penetrates the cortical cells of the roots of vascular plants in this kind of mycorrhiza.

h) Silicate Solubilizing Bacteria

Microorganisms, such as *Bacillus* spp., are capable of decomposing silicates and aluminium silicates and play a dual function in silicate weathering.

i) Plant Growth Promoting Rhizobacteria

Rhizobium spp., *Azospirillum* spp., *Arthrobacter* spp., *Bacillus* spp., *Burkholderia* spp., *Pseudomonas* spp., *Frateuria aurentia*, and other bacteria belong to this category. Liquid Biofertilizers are now available, and they have several advantages over solid inoculums, including a longer shelf life (12-24 months), no contamination, no loss of properties in storage up to 45 °C, greater potential for fighting native populations, easy identification by a characteristic fermented odour, better seed and soil survival, ease of use by farmers, high commercial revenues, and high export potential.

Application-Method of Applying Biofertilizers to Crop

There are three methods as follows.

a) Seed Treatment

This approach involves mixing 200 g of nitrogen and phosphorus fertilizers in 300-400 ml of water. Then, by hand, spread this slurry over 10-12 kg of seed. After that, the seeds are dried in the shade and planted right away. It is always recommended to coat wet biofertilizer treated seeds with 1 kg of slaked lime or gypsum powder for acidic and alkaline soils, respectively.

b) Soil Treatment

The quantity of biofertilizers and compost fertilizers combined together is determined by the number of seedlings per acre. The compost incubation was held overnight. The mixture is then placed on the soil where seeds must be sowed the next day.

c) Seedling Root Dip

The plant roots are suspended in 1-2 kg of nitrogen fixing and Phosphate solubilizing microorganisms in just enough water (5-10 litre) to cover the seedlings required to cover one acre. Before transplanting, soak the seedlings in this suspension for 20-30 minutes.

Advantages of Biofertilizers

Biofertilizers make a unique contribution to agriculture production and soil health because of the following benefits.

• They provide nutrients and beneficial microbes to the soil, which are essential for plant growth.

• Biofertilizers eliminate the harmful components in the soil that cause plant diseases.

• Using biofertilizers, plants can also be protected from drought and other harsh conditions.

• Biofertilizers are inexpensive and can help to reduce the use of chemical fertilizers.

• Biofertilizers use microbes to deliver nitrogen from the atmosphere directly to plants.

• Hormones, vitamins, auxins, and other growth-promoting chemicals are better synthesized and available, which increases plant growth.

• Their use increases agricultural output by 10-20 percent on average.

• They aid in the survival and proliferation of beneficial microorganisms in the root zone (rhizospheric bacteria).

• They are effective at controlling and inhibiting harmful soil microorganisms.

• They improve soil texture by adding compost and keep soil fertility in check.

• Environmentally friendly and pollution-free.

Challenges with Biofertilizer

Lack of awareness of the eco-friendly importance of microbial biofertilizer among farmer communities, insufficient promotion and motivation by agricultural extension workers to farmers on the use of biofertilizer product, lack of availability of suitable carriers for biofertilizer formulation, lack of storage facilities to prevent contamination of the biofertilizer product, and extreme weather are the major challenges with the application of microbial biofertilizer. Furthermore, absence of labeling, such as the expiration date and the identity of microorganisms employed in the biofertilizers' creation, might smear the credibility of biofertilizer goods, and most biofertilizers are selective in their actions (Timmusk *et al.*, 2017; Naveed *et al.*, 2015).

Prospects and Conclusion

The utilization of microbial biofertilizers as a significant component of modern agriculture is critical, due to its renewable, low-cost, and environmentally benign potential in assuring long-term agricultural sustainability. Importantly, the use of biofertilizer as an integral component of agricultural practice in improving plant yield has lately gained traction in addressing the world population's demand for food supply. In some underdeveloped nations, using mycorrhizal fungi and PGPR to make biofertilizers for rhizosphere management has proven to be successful, and this trend will continue. Furthermore, the novel technology involving the addition of nanoparticles derived from organic and inorganic materials to plant growth-promoting microorganisms will continue to gain popularity over time.

In this Conclusion of despite their promising results, biofertilizers have yet to find widespread use in agriculture due to the diverse responses of crop species to bacterial strains inoculated in inoculation medium. Bacteria having a high saprophytic mode and a good competitive mode become essential components in biofertilizer performance. In the realm of biofertilizers, further study is needed to generate strains that are easy to inoculate into host systems and prove effective in field conditions. The existing use of chemical fertilizers has resulted in environmental contamination and increased the expense of agricultural operations, indicating that biofertilizer research has a bright future.

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