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Review Article

# Sustainable use of Biofertilizer & Their Role in Agriculture

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## ABSTRACT

Chemical fertilizers have long been used to meet the soil's nutritional and production needs, but excessive usage of these fertilizers can harm the environment, beneficial bacteria, animals, and people. Consequently, economical and ecologically friendly Biofertilizer are applied. Biofertilizer are materials that contain microorganisms that Fungi, bacteria, and protozoa are examples of microorganisms that can boost the fertility of soil through iron sequestration, phosphorus solubilisation, and nitrogen fixation. By converting insoluble nutrients into soluble forms, these processes make them accessible to plant roots, which can readily absorb and use them. Rice, oats, and other grain crops are among the many crops whose productivity can be raised by using Biofertilizer. We go over how to apply Biofertilizer in this overview, how they benefit plants, and in which they are beneficial.

## KEYWORDS

• Biofertilizer • PGPR • Auxin • Rhizobium.

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## INTRODUCTION

The need for food is rising quickly due to the world's growing population.[1,2] Because the population needs food on a daily basis, the demand for food is rising in developed nations where land resources do not contribute to agricultural production. People first apply chemical fertilizers, which boost crop output, to increase the land's capacity to produce more. However, the prolonged use of chemical fertilizers has a negative impact on the ecosystem.[1,3,4]Along with decreasing the soil's holding capacity and increasing salinity and nutrient disparities, these pollutants also damage soil fertility.[1] Therefore, Biofertilizer are the target. These were employed to lessen the negative effects of environmental stress, biotic stress (such as infections and other microbes), and low soil fertility.[5-7] Many organic fertilizers have been introduced in recent years as a result of the extensive work done in this area. These serve as organic growth and development promoters for plats.[8-10.] On the basis of plant growth promoting microorganisms (PGPM), a significant class of organic fertilizers was developed. There are numerous types of microorganisms that are good for plants, however the main The following three factors are thought to be crucial for plant growth: Mycorrhizal arbuscular fungus[10,11] *Rhizobacteria* that promote plant growth and bacteria that fix nitrogen but are not classified as PGPR[4,10] Biofertilizer are substances that include living microorganisms that are applied to seeds, plant surfaces, soil, or the rhizosphere to create colonies or the inside of the plant. They encourage plant development by raising the provision of basic nutrients to the host or making them available[10,12] Biofertilizer are principally employed to boost microbial activity, which raises the availability of nutrients that plants can readily absorb.[1,13,14] Organic fertilizers are encouraged so that plants can obtain nutrients naturally[15] as well as boost the mobilization[16] can improve soil fertility and boost crop productivity.[17,18]

## WHY BIOFERTILIZER ARE NECESSARY

Chemical fertilizers can meet the needs of rapid growth and a large supply of food, but they can harm the environment by raising pH, killing beneficial insects, and harming microbial biota. Nevertheless, the application of artificial fertilizers makes the disease-prone crops that also cause a decline in soil fertility[5,19] According to estimates, the world's population will surpass 8 billion people by 2020, and in order to feed them, 28.8 million tones of food and nutrients would be needed; however, only 21.6 million tones will be available to the global community.[20]

In order to feed everyone on the planet, we must expand agriculture and boost productivity in a way that benefits everyone and has no negative effects on the environment, beneficial insects, humans, etc. To do this, we must boost agricultural output using insecticides, fungicides, herbicides, pesticides, and chemical fertilizers.[21]

As was already mentioned, because of the harmful effects, we are shifting away from chemicals and towards safer, more efficient, environmentally friendly, and more affordable alternatives. Bio-fertilizers offer all of these qualities.[22]

Like other artificial chemicals, Biofertilizer are commercial goods that contain helpful microorganisms, compounds necessary for microbial growth, and additional additions that may potentially promote microbial growth. According to reports, using Biofertilizer increases the amount of nutrients in meals. nitrogen, vitamins, protein, amino acids, and other vital components from renege 10% to 40%[23] The plant receives both macro and micro needed nutrients for growth from the Biofertilizer, which also aids in the provision of hormones and other organic materials.[24] The best and most natural way to maintain the bios stem's activity and functionality is to apply Biofertilizer; the microbes in the soil give plants nutrients and contribute to the preservation of biodiversity by enhancing the soil's quality.[25]

## WORKINGS OF BIOFERTILIZER

Bacteria, fungi and other microorganisms an important and unequally distributed micro-organism located everywhere in the environment with varied amount of concentration present in more concentration near the root and do very important works. Bacteria which are present near the roots (rhizosphere) have the power to stimulate plant growth consequently are referred as plant growth boosting microbes, the bacteria which play its role as a plant growth promoter are designated as plant promoting bacteria or (PGPB). Today several of the PGPB are available on commercial scale as a bio fertilizers.[26]

Plant development and soil fertility are significantly impacted by PGPB. It plays a dual role.

PGPBs assist provide critical elements like nitrogen through nitrogen fixation, phosphorous through phosphorous solubilisation, and potassium. They also supply crucial hormones like auxins, cytokine, and gibberellins, which directly affect plant growth. Intake - also referred to as the "direct way."

supporting the genes that defend against infections in a variety of methods that are referred to as indirect ways.[27]

## DIRECT WAY OF ACTION

### Auxin

Auxin is a hormone involved in stem root extension, cell division, tissue differentiation, and geo and phototropism.[28] PGPBs have a beneficial impact on plant growth because they can create auxin, which is produced by 80% of the microorganisms in the rhizosphere together with their secondary metabolite.[29] Rhizobacteria alter the concentration of auxin in the form of indole-3-acetic acid (IAA), which can increase the surface area of roots and significantly increase the quantity of auxin that plants absorb. Keep in mind that several studies have shown that auxin and IAA are Comparable.[30]

Auxin has varying degrees of sensitivity in different plant cells.[31] IAA is produced by the PGPB and functions as auxin; when the IAA concentration is below ideal, roots will grow, and when the shoots are at their best.[27,32]

### Ethylene

The hormone ethylene is crucial for regular growth and cell division in plants. It also plays a big part in protecting the plants from various biotic and abiotic pressures.[33] Nearly every plant, regardless of stage, is impacted by ethylene, which is impacted by a variety of biotic and abiotic stressors as well as plant hormones, temperature, gravity, light, and nutrition.[27]

High levels of ethylene aid in the plant's ability to adapt to a variety of challenges, including those caused by infections, drought, light, chemicals like salts, and temperature.[34,35]

The PGPB forms a link with plant roots, converting some of the tryptophan that the plant releases into IAA, which is then produced by bacteria and absorbed by the plant.[36]

### Cytokinins

Higher plants, bacteria, fungus, and algae all contain cytokinins. We knew very little about the function of the microorganisms that produce cytokinins. Root tips produce cytokinins, which are then transferred to shoots via xylem.[37] It regulates the differentiation and division of meristem cells.[38]

Cytokinin genes are found in many PGPBs, and when they are introduced to nearby plants, the plant's growth and other phytohormone configurations rise.[37]

The growth of plants was changed when Bacillus subtilis was utilised as a cytokinin-producing agent. Similarly, when Sinorhizobium melioti overproduced cytokinin, which was used as a test for lucerne plants against drought stress, the results showed that.[38]

### Gibberellin (GA)

A class of teracyclic diterpenoid carboxylic acids with C20 or C19 is present in gibberellin.[39] In addition to other crucial processes including stem elongation, seed germination, fruit sitting, and plant flowering, gibberellins activate and stimulate plant growth.[40]

And also influence plant growth via the GAs signalling pathway.[37] We easily eliminated the lack of GAs as a decrease in the quantity and length of side roots since the biochemistry of bacteria and plant-produced GAs is similar.[41]

It is still unknown how GA is produced in bacteria, although it is known in plants and fungi.[37] Two bacteria that can make GA have been isolated: Bacillus pumilus and Bacillus licheniformis.[42]

### Nitrogen fixation

One crucial macroelement that is necessary for plant growth is nitrogen. Additionally, it is necessary for the synthesis of proteins, chlorophyll, and nucleic acids. About 78% of the atmosphere is made up of nitrogen.[43,44]

The gaseous form of this makes it unavailable to plants. There are several nitrogen fertilisers produced by industries that boost agricultural output.[37,45,46] By converting atmospheric nitrogen into a form that plants can easily absorb, such ammonia, biological microbial fixation takes place.[45,47]

Ammonia production from nitrogen Due to the triple bond in the N2, a significant quantity of energy is needed. Numerous bacteria that fix nitrogen have been found; these bacteria work symbiotically with plants like legumes to fix nitrogen. Among them are *Rhizobium*, such as *azorhizombium* and *sinorhizombium*.[7,25]

On the root cells, rhizobial bacteria establish colonies and begin the formation of root nodules.[37] Because they lack a cell wall, the bacteria in this situation function as bacteroid organisms, fixing nitrogen with the aid of the nitrogenase enzyme and turning it into ammonia. The plant reciprocates by giving them the fixed carbon, demonstrating mutualism. Various Commercially, rhizobia species are employed to provide crops with nitrogen in a form that they can absorb.[48]

**Rhizobium:**

They are rhizobacteria that fix nitrogen and are members of the Rhizobacea family. It consists of *Azorhizobium, Mesorhizobium, Sinorhizobium, Bradyrhizobium,* and *Rhizobium*. Mutualistic relationships exist between them and the roots of leguminous plants, and free-living ones repair the Diazotrophs are nitrogen-producing plants that are not legumes.[49]

The process is complicated and involves multiple enzyme complexes, such as nitrogenase, which contains dinitrogenase reductase, which contains iron (Fe) and molybdenum (Mo) as a cofactor.[50] Nitrogen is necessary for Rhizobium sp. respiration, and it uses electrons to convert N2 to NH3.[4]

Three distinct types of nitrogenase complexes exist, contingent on variations in the dinitrogenase cofactor. The three nitrogenases are Mo-, V-, and Fe-.[51] In free-living and nitrogen-fixing organisms, several genes known as "Nf" genes are crucial for nitrogen fixation.[52]

Activation of the Fe/Mo cofactor, electron donation, cofactor production, and the regulation and operation of enzymes are all mediated by the Nif genes.[53] Research indicates that plants inoculated with the Rhizobium wild type strain Retile 68% exhibited increased nirtogenase activity, with a 25–30% rise in leaf contents and a 16% increase in seeds.[54]

**Azospirillum:**

*Azospirillum* are gram-negative bacteria that are members of the *Spirilaceae* family and have the capacity to fix nitrogen.[2]

*Azospirillum lipoferum* and *A. brasilense* are the most advantageous species in this genus, while other species such as *Azospirillum amazonense, Azospirillum halopraeferens,* and *Azospirillum brasilense* are also present.[20]

They form symbiotic relationships with plants, particularly those that use the C4dicarboxylic route for photosynthesis.[55] They generate plant regulators such as IAA, GA, and cytokinin, which aid in root development and allow plant.

***Azotobacter:***

They belong to the *Azotobacteriaceae* family of free-living, aerobic, photoautotrophic, non-symbiotic bacteria that are crucial to the nitrogen cycle of plants. Usually found on arable soil, they can be found in areas with alkaline soil.[57]

*Azotobacter* common species include *Azotobacter vinelandii, Azotobacter beijerinckii, Azotobacter insignis*, and *Azotobacter macrocytogenes.*[20]

According to reports, these bacteria create a variety of hormones, including as gibberellins and naphthalene acetic acid, which increase the uptake of minerals and nutrients by plants and inhibit the development of root pathogens. Additionally, vitamins like vitamin B complex are made by the bacterium in question. Numerous crops, including rice, maize, sugarcane, and vegetables, contain these kinds of bacteria. *Azobactor* is crucial for the synthesis of several other vitamins, including thiamin and riboflavin.[58]

***Azolla* and Blue-green algae:**

*Azolla* has sp *Azolla filiculoides, Azolla microphylla, Azolla caroliniana*, and *Azolla mexicana*.[20] These are abundant in rice fields and belong to eight different families. They produce many hormones, including gibberellic acid and indole acetic acid, which promote plant growth.[20] In order to boost output A necessary mineral for that is nitrogen, which is supplied to rice plants through biological nitrogen fixation.[4,59] Azolla has a dry nitrogen content of 4-5% and a wet nitrogen content of 0.2-0.4%. Azolla is a crucial organic fertiliser because it gives rice plants nitrogen.[20] Additionally, it may quickly break down soil and supply plants with essential nutrients like potassium, phosphorus, iron, zinc, and other microelements.[60]

### Phosphate solubilization

The term "phosphate solubilising bacteria" refers to the microorganisms that dissolve phosphorus. Those bacteria [37,61] These bacteria provide plants with phosphorus in a form that can be transferred to the environment. These bacteria change the types of phosphorus found in the environment, like organic and inorganic phosphate, into forms that plants can use. They are impacted by numerous factors, including the soil, the environment, and the bacterial species that are present.[62,63] *Rhizombim* and *Bacillus* are the genera that contain the potent organisms that solubilise phosphorus.[37,64] The initial step in the phosphorus solubilisation process is the use of mineral dissolving agents.[65,66] For example, CO2, ions, and other organic molecules Then, the chelates of the oh ions present and the organic molecules generated result in a reduction in PH and the release of phosphorus. Following that, the bacteria generated organic acids, which were then expelled by the phosphate-solubilizing bacteria.[67]

### Iron uptake

Plants need iron in a variety of vital processes, including the photosynthetic system, chlorophyll for light absorption, and other metabolic processes. The soil's iron content is insufficient for the plants. Despite being abundant on Earth, iron cannot be used because it is present in an insoluble form in microorganisms and plants. The bacteria use the following process to transform them into a soluble form. Siderophores are substances they expel that bind to iron. These molecules bind to iron with a high degree of affinity. Following their absorption, these soluble complexes are transformed into ferrous or iron by bacteria or plants. Siderophores are small molecules with groups that bind iron.[37,68,69]

### Indirect methods

In many developed nations, a variety of plant diseases are reducing plant production by roughly 10%.[37]

The PGPB is being promoted by the scientists in the event that the chemicals decline.

### Antibiotics

PGPBs produce antibiotics that work against the pathogen and shield the plant from the disease, thereby reducing the impact of various pathogen attacks. The PGPBs generate distinct antibiotics under various circumstances. We can change the PGPBs that make antibiotics in labs.[70]

### Cell wall degrading enzymes

Enzymes that break down cell walls are produced by certain plants and work against fungus. for instance, the plant-produced enzyme chitinase, which breaks down the fungus's chitin. When the PGPBs were being studied in the lab to become an energetic biocontrol agent. Therefore, the PGPBs safeguard the plants by breaking down the fungus's cell wall.[42]

### Hydrogen cyanide

A lot of PGPBs generate hydrogen cyanide. To combat a variety of illnesses, hydrogen cyanide is employed as a biocontrol agent. Plants cannot be attacked by fungal infections due to the low hydrogen cyanide levels. As a result, the PGPBs exhibit efficient disease resistance by generating hydrogen cyanide. Inhibiting cytochrome c oxidase and its other metabolites is how hydrogen cyanide functions. Numerous bacteria, including Rhizobium, Pseudomonas, and Bacillus, also make HCN.[37,71]

## APPLICATION OF BIOFERTILIZER

### Growth in crops and plants:

Numerous uses of microbial fertilisers inspired researchers to look for microorganisms that can either directly or indirectly raise plant nutrient standards, hence promoting plant growth.[2]

Some PGPR pose as biofertilizers in order to stimulate growth. Bacteria that promote plant development are crucial for the synthesis of hormones that control growth. They strengthen the plant's roots and boost its ability to absorb nutrients.[72] Plant length, branch count, root and shoot length, and the accumulation of dry matter in plant organs are all greatly increased by biofertilizers. PGPR differ in the way they Inorganic phosphate solubilisation and the synthesis of plant growth regulators are the two main ways that plant growth activity affects plant growth. B. megaterium, a bacterium that promotes plant growth, improves root formation and growth, which leads to improved nutrient utilisation.[68] By encouraging the growth of roots, Azospirillum species are known to boost the yield of cereal and forage grasses. Azospirillum helped the plant by increasing the bacterial capacity to fix nitrogen in the plant's rhizosphere. It was facilitates the growth of roots and shoots.[73s]

**Enhancing the yield of crops:**

By reducing fertiliser dosages and harvesting high-quality nutrients from the soil, biofertilizers can be utilised as an affordable input to increase crop output. The production process for biological fertilisers is straightforward and reasonably priced in contrast to plants treated with synthetic fertiliser. Biofertilizers multiply and contribute to the ecological cycle of nutrients when used as soil inoculants, which has been beneficial for crop output.[74] Frequently inoculating plants with extremely powerful rhizobacteria has improved their growth and yield.[25]

**Biofertilizer's function in photosynthesis**

Since photosynthesis accounts for around 90% of the plant's body, higher photosynthesis enhances the plant's growth rate.[75] Certain strains of Rhizobia were shown to significantly enhance the surface area of plant leaves, photosynthetic rate, stomatal opening and closure, and water availability efficiency, indicating that the Rhizobial treatment can enhance a plant's capacity for photosynthetic activity.[76] The majority of a plant's photosynthetic organs, or chlorophyll, are its leaves. Consequently, the quantity of leaves is crucial. Increasing the number of leaves could encourage rapid root growth and enhance plant roots' ability to transport water, as well as the yield and mineral accumulation.[37]

**Cost Effective:**

When in use, biofertilizers improve soil fertility without having any negative effects on the soil and are far more economical. A sustainable agricultural system is required, where soil fertility is essential. Maintained through the use of reasonably priced, renewable resources, like biological fertilisers. The desire to lower the cost of fertilising crops with renewable energy sources has brought biofertilizers back into the spotlight globally. Because it is readily available and has a higher nitrogen content than pricey inorganic or synthetic fertilisers, chicken dung is a biofertilizer that farmers can easily afford.[2]

**Mode of action of bio-fertilizer**

There are numerous methods for applying biofertilizers to the soil.

Dry biofertilizers vary depending on the type of seed.

Powdered biofertilizers added to soil.

This technique, known as the "ass sprinkle method," involves adding a small amount of water to the seed hopper before adding biofertilizers.

The slurry method involves using biofertilizers in water in a suspended state before adding them to seedlings.

Seed pelleting technique (applying biofertilizer to the seed).

The seed is coated with compounds that resemble lime after the seed and biofertilizers are combined in a slurry and adhesive is applied.

The peat suspension was sprayed into the furrow while it was being sown.

Treatment of seed inoculation.

Use in root dips or seed links.[77]

## FUTURE PERSPECTIVE

For many years, traditional techniques like chemical fertilisers were used to support the growth and development of plants.[61,78,79] They boost yield production to a certain extent, but they also pollute the environment and use chemicals that are harmful to both beneficial microbes and humans. A review unequivocally demonstrates that biofertilizers are the source of the growth. and the amount of nutrients in crops. In the field of biofertilizer, which is still in its infancy, a variety of microbes are employed to boost crop yields and shield them from various pathogens. The application of biofertilizers is very beneficial and is thought to grow with time.[80] However, a few problems with biofertilizers will need to be solved in the future, and those problems will need significant work.[27]

## CONCLUSION

At the end of our review, we came to the conclusion that microbial fertilisers are crucial for crop improvement today. The usage of biofertilizers is necessary for two reasons. First, they give human food the inevitable quantity of production and nutrients, which is extremely eco-friendly and safe for usage by humans, plants, and animals. The second is that they supply nutrients like N, P, and K, as well as other minerals and vitamins, to plants in the rhizosphere, ensuring the agriculture industry's sustained expansion. Several kinds of microorganisms, such as PGPB and fungi, are employed for this purpose and are quite effective.

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