**Role of Bio-Fertilizer for Improving Soil Health**

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**ABSTRACT**
Continuous deterioration of earth’s natural resources and increased use of hazardous chemical fertilizers pose a great anxiety for the future of agriculture. Biofertilizers are a hopeful alternative to hazardous chemical fertilizers and are gaining importance for achieving sustainable agriculture. Biofertilizers play a key role in increasing crop yield and maintaining long-term soil fertility, which is essential for meeting global food demand. Microbes can interact with the crop plants and augment their immunity, growth, and development. Nitrogen, phosphorous, potassium, zinc, and silica are the essential nutrients required for the proper growth of crops, but these nutrients are naturally present in insolubilized or complex forms. Certain microorganisms render them soluble and make them available to the plants. Biofertilizers, being cost effective, non-toxic, and eco-friendly, serve as a good substitute for expensive and harmful chemical fertilizers. This can help us to understand the importance of microbes in agriculture for sustainable crop production.

**INTRODUCTION**
One of the present-day challenges in agriculture is eco-friendly practices. Though the benefits of green revolution have been earned by us in terms of production, the other side of it, i.e., over usage of chemical fertilizers and its subsequent corrosion of soil health has been comprehended these days and also chemical fertilizers are toxic and pollute the water and disturb the ecological balance. This, coupled with the low purchasing power of small and marginal farmers continues to be the major concern in our agricultural production process and at the same time we are not able to provide them a
nutritional diet. However, excessive use of chemical fertilizers has led to several issues such as serious soil degradation, nitrogen leaching, soil compaction, reduction in soil organic matter, and loss of soil carbon. In addition, the efficacy of chemical fertilizers on crop yield has been decreasing over time.

**BENEFITS OF BIO-FERTILIZERS OVER CHEMICAL FERTILIZER**

Use of biofertilizers has several advantages like Biofertilizers improve soil texture, structure, supply of nutrients, water holding capacity and proliferate useful soil micro-organisms. Biofertilizers are cheaper, renewable and pollution free. Besides being non-toxic, biofertilizers have some distinct advantages over chemical fertilizers. Biofertilizer like blue green algae is capable of providing more nitrogen, an important nutrient for plants than all chemical fertilizers put together. as well like they are cost effective, eco-friendly and renewable source of plant nutrients hence forms one of the important components of integrated nutrient management. As of now we could not claim bio-inoculants as a right alternative to chemical fertilizers but in near future the scientific understanding of the same will pave way for its right use and reap full benefits.

**TYPES OF BIO-BIOFERTILIZERS**

Based on type of microorganism, the biofertilizer can also be classified as follows:

**Bacterial Biofertilizers:** e.g., Rhizobium, Aspergillum, Azotobacter, Rhizobacteria.

**Fungal Biofertilizers:** e.g., Mycorrhiza

**Algal Biofertilizers:** e.g., Blue Green Algae (BGA) and Azolla.

**Actinomycetes Biofertilizer:** e.g., Frankia.

**MECHANISM OF BIO-FERTILIZERS FOR IMPROVING SOIL HEALTH**

**Role of Biofertilizers in Increasing the Soil Organic Carbon**

The application of bio-fertilizers that contain living microorganisms is one of the management practices that can help to maintain or increase the content of organic matter and improve soil fertility in arable soils. the influence of bio-fertilizers on the acceleration of the humification of fresh organic matter that is introduced into the soil, that is why, especially when a large amount of exogenous organic matter (e.g., natural fertilizers or different bio-wastes) is introduced into the soil, the application of specially composed bio-fertilizers is very important in order to accelerate the transformation of the biomass.

**Nutrient Transformation**

Biofertilizers comprise a promising tool in agricultural ecosystems as a supplementary, renewable and eco-friendly source of plant nutrients. As they have an ability to transform nutritionally important elements from nonusable to highly assimilable forms without deleterious effects on natural environment, they are an important component of Integrated Plant Nutrient System. Application of biological fertilizers is thought to be a key element in maintaining soil fertility and crop productivity on the sufficiently high level, indispensable to achieve sustainability of farming.

**Biological Nitrogen Fixation**

Biological N₂ fixation (BNF) is an important biochemical process associated with plants kingdom. The BNF is carried out by certain bacteria, actinomycetes, blue green algae, fungi and yeast. The most important of these are the bacteria, which have the ability to fix the atmospheric N₂ in symbiosis with the plants or as free-living organisms (non-symbiotically). Symbiotic N fixation is of more importance and the amount of N fixed is quite appreciable.
Biofertilizers are microorganisms, which can bring about soil nutrient enrichment. Among these, symbiotic (Rhizobia species) and non-symbiotic fixers of N (Azotobacter and Azospirillum) are commonly used in agriculture. Free living blue-green algae in rice fields can provide 10-20 kg N/ha, while azolla, a fern, in association with blue-green algae, can supply 30-40 kg N/ha. However, these biofertilizers alone cannot meet the N requirement of crops and their use has to be integrated with fertilizer N to get a good yield.

Role in Solubilizing Phosphorous

Application of PSM by inoculating in soil appears to be an efficient way to convert the insoluble P compounds to plant-available P form, resulting in better plant growth, crop yield, and quality. *Bacillus*, *Pseudomonas*, *Rhizobium*, *Aspergillus*, *Penicillium*, and AMR are the most efficient P solubilizers for increasing bioavailability of P in soil. PSM provokes immediate plant growth by providing easily absorbable P form and production of plant growth hormones such as IAA and GA.

Potassium Mobilizer

Some of the soil microorganisms are well known for the solubilization of potassium from K minerals. Most of the micas, i.e., orthoclase, mica, illite, and muscovite, are the source of K in soil; with the reaction of microorganisms, produced organic substances solubilize the K and enhanced the soil solution, these organisms also produce various types of amino acids, growth-promoting compounds (IAA and gibberellic acid), and vitamins, which promote the crop growth and yield. *Frateuria aurantia* is well known for the mobilization of K from the mica; it also works in association with other biofertilizers in positive mode and enhances the soil productivity and fertility.

Zinc Mobilizer

Across the globe, Zn is known as one of the micronutrients and its deficiency limits the growth of crop and adversely affects the crop yield. The Zn fertilizers are more costly and its availability is also limited. In this regard the use of Zn solubilizers can play a vital role in enhancing the yield and quality of crops. Some of the microorganism species are isolated, which are responsible for Zn solubilization, i.e., **Bacillus** sp. The external applications of Zn fertilizers, soluble zinc sulphate (ZnSO4), are more common in all crops. The applied soluble Zn fertilizers during crop get into plant available form after reaction with soil constituents. Acid soil cation exchange and high-pH soil chemisorption’s (Zn-CaCO3) or complexation by organic ligands fix the Zn in soil and reduce the concentration in soil solution. The microorganisms that are well known for the solubilization of Zn are **B. subtilis**, **Thiobacillus thiooxidans**, and **Saccharomyces sp**. These strains are used for Zn biofertilizers and get positive response among the farmer communities.

EFFECT OF BIOFERTILIZERS IN SOIL PROPERTIES

It can be said that in general the application of bio-fertilizer gave significant effect to almost all of soil parameters. This condition can happen because the symbiotic relationship between AM fungi and a variety of plants that can produce colonies on the outside part in a root system. This condition can make the uptake of water and nutrients by the plant roots increases. The AM fungi can improve plant performance under drought stress through the increase in absorption of water and some nutrients. That are zinc (Zn) and copper (Cu),
and also plant variables like a leaf height, leaf water turgidity, stomatal activities, and root growth. The AM fungi performance as an agent which can improve plant-water relationship through increasing stomatal resistance by adjusting plant hormonal balance. Moreover, through this chain, the P element can increase by the activity of AM fungi in a growth phase. The AMF symbiosis can also increase the absorption of other nutrients such as P, N, Cu and Zn. Beside that process, the additional material combined with biofertilizer (growing substrate, humic acid and Phyto-compound) can make the performance from this product much better. This is supported, that humic acid has a role in the release of P adsorbed in the soil and can increase the availability of P in the soil. Humic acid can replace phosphate ions by sorption’s mechanism and also has the ability to binding the organic compounds. This process can happen because the negative charge on the functional groups in the humic acid has the ability to react and interact with positively charged ions.

CONCLUSION

The use of microbial biofertilizers as a key to modern agriculture is fundamental, based on its renewable, low cost, and eco-friendly potential in ensuring sustainable agriculture. Importantly, the application of biofertilizer as an integral component of agricultural practice in promoting plant yield has gained more traction recently in meeting the demand of food production of the world populace. In conclusion, overdependence on the use of chemical fertilizers has encouraged industries to produce chemicals that are toxic to human health. Thus, causing ecological imbalances. These drawbacks are combined with a high cost of production that is beyond the means of many farmers in the developing world. The application of biofertilizers is eco-friendly, relatively inexpensive, nontoxic, and possesses the significant potential to increase plant yield. Thus, the function of plant growth-promoting microorganisms and the application of biofertilizer made from viable microbial strains to the field bodes well for successful management of the rhizosphere for sustainable agriculture.

REFERENCES


