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Bio-fertilizer: A Novel Tool for Agriculture

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SUMMARY

Plants nutrients are essential for production of crops and healthy food for the world's ever increasing population. Soil management strategies today are mainly dependent on inorganic chemical based fertilizers, which cause a serious threat to human health and environment. Bio-fertilizer or the exploitation of beneficial microbes, an important component of integrated nutrient management, has been identified as an alternative for increasing soil fertility and crop production in sustainable farming and has imparted paramount importance in agricultural sector due to their potential role in food safety. Microorganisms that are commonly used as bio-fertilizer include nitrogen fixers, potassium and phosphorus solubilisers, growth promoting Rhizobacteria, endo and ecto mycorrhizal fungi, cyanobacteria and other useful microscopic organisms which can lead to improved nutrient and water uptake, plant growth and plant tolerance to abiotic and biotic factors. These potential biological fertilizers would play a key role in productivity and sustainability of soil and also in protecting the environment as eco-friendly and cost effective inputs for the farmers.

INTRODUCTION

Sustainable agricultural development and yield maximization of crops in intensive cropping systems can be achieved through restoration and scientific management of land productivity for which supply of appropriate source and amount of nutrients are indispensable. In conventional practice, improved cropping systems involving high value crops rely on the use of chemical fertilizers due to its immediate availability of nutrients. Though chemical fertilizers nourish plants but also jeopardize the environment through nitrate pollution and create adverse effects on the fragile ecosystem with elimination of beneficial soil microorganisms and deterioration of soil physico-chemical properties. Indiscriminate and continuous use of such chemical fertilizers leads to instability in yield and also poses a threat to soil health particularly due to micronutrients deficiency and fertilizer related environmental pollution (Prasad and Power, 1995). Moreover, the produce so developed may raise a question about its quality and acceptability in market. A growing consciousness of such overdependence on synthetic chemicals and the associated degradation in product and environmental quality led to the emergence of a farming system known as 'organic farming'. For restoration and augmentation of soil fertility and improvement of crop yield and quality in intensive cropping system, organic farming practice can be an option. In this regard, attempts have recently been made towards the production of nutrient rich high quality fertilizer or bio-fertilizer to ensure bio-safety. Bio-fertilizer has been identified as an alternative to chemical fertilizer to increase soil fertility and crop production in sustainable farming. They are defined as products containing active or latent strains of soil microorganisms, either bacteria alone or in combination with algae or fungi that increase the plant availability and uptake of mineral nutrients (Vessey, 2003). The bio-fertilizers include mainly nitrogen fixing, phosphate solubilizing and plant growth promoting microorganisms. Hence, bio-fertilizer can be an important component of integrated nutrient management practices for sustaining agricultural productivity and a healthy environment and furthermore, the potential of application bio-fertilizers in terms of increased nutrient profiles, crop growth and yield and an improved tolerance to environmental stress should be encouraged.

What is Bio-Fertilizer?

A bio-fertilizer is a substance containing living strains of microorganisms which can add several important nutrients through the natural processes of nitrogen fixation, phosphorus solubilization and stimulation of plant growth through synthesis of growth promoting materials and colonize the rhizospheric region or interior of the plant, thereby promoting growth and development by the means of enhancement of supply or availability of primary nutrients to the host plant when applied to the seeds, plant surfaces or soil. It is a modernized or improved form of organic fertilizer into which certain beneficial microorganisms have been incorporated. Bio-fertilizer is frequently referred to as selected strains of profitable soil microbes cultured in laboratories and compacted with convenient carriers and involves almost all types of organic resources required for plant growth

which are rendered in available form for absorption by the plants through microorganisms or plant associations or interactions.

Advantages of Bio-Fertilizers

- The microorganisms present in bio-fertilizers can help to restore the soil's natural nutrient cycle and build up soil organic matter.
- It aids in healthy plant growth and development including the enhancement of sustainability and fertility of our resource base or soil.
- It may decrease the utilization of synthetic/inorganic/chemical fertilizers and pesticides, thereby ensuring the environmental sustainability.
- Bio-fertilizers provide eco-friendly organic agricultural input.
- It can improve the nutrient availability in soil and its uptake in plants.
- The microbes in bio-fertilizers can symbiotically associate with plant roots and fix atmospheric nitrogen, solubilises native phosphorus readily and safely convert complex organic materials into simple compounds; hence improving the easy absorption of nutrients by the plants.
- Bio-fertilizers on long term basis help to improve the soil fertility status by maintaining the natural habitat of soil and recycling nutrients.
- It increases crop yield by 20-30%, replaces chemical nitrogen and phosphorus by 30%, and provides protection against drought and some soil borne diseases.
- They promote vigorous shoot and root growth of many crops.
- Bio-fertilizers or microbial nutrients/bacterial or fungal inoculants contain living cells of different microorganisms that mobilize nutritionally significant elements from non usable to usable form through biological processes.
- Recently they are emerged as a vital component of Integrated Nutrient Supply System or INSS thereby improving crop yields and nutrient supplies with minimal use of non-renewable resources.
- It holds a promising position to increase germination up to 20 percent and improve seedling emergence and growth.
- Bio-fertilizers can improve the quality of fruit and their keeping quality also; save 25 to 35 percent inorganic fertilizers and improve the texture, structure and water holding capacity or the physical and chemical properties of soil as well.
- They do not allow pathogens to flourish, reduce the risk of plant diseases, protect the environment from pollutants and destroy many harmful substances present in the soil.
- Microbial inoculants are eco-friendly and cost-effective and proved to be efficacious even under semi-arid conditions.
- They are the natural form of fertilizers and hence, widely used in agriculture.
- Bio-fertilizers have the ability to decrease human and animal hazards by reducing the level of poisonous residues in agricultural products, ensure the optimum utilization of natural resources and above all, reduce the risk of crop failure.
- Nevertheless, they carry out several responsibilities; a much preferred scientific term is given to those beneficial organisms which are known as ‘Plant Growth Promoting Rhizobacteria’ (PGPR).

Applications of Bio-Fertilizers

- Seedling root dip: This method is particularly applicable to rice in which the seedlings are planted in the bed with water for almost 8-10 hours.
- Seed treatment: The seeds are generally dipped in the mixture of nitrogen and phosphorus fertilizers, and then they are dried and sown as early as possible.
- Soil treatment: In case of soil treatment, different bio-fertilizers along with composts are mixed and kept for one night and thereafter it is spread on the soil surface where the seeds have to be sown.

Limitations of Bio-Fertilizer

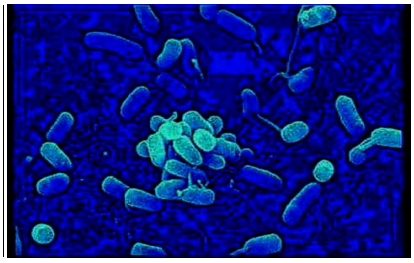
- In general, bio-fertilizer provides quite lower nutrient density which might lead to deficiency symptoms in plants grown with the bio-fertilizers; hence, it is required in large quantities for crop cultivation to meet the requirement of nutrients.
- The application requires a different type of machinery rather than that is used for chemical fertilizers.
- It requires specific skills in production and application as well.
- Lack of adequate awareness among farmers about the usefulness and benefits of bio-fertilizers in increasing crop yields is a major hindrance and they are also ignorant of the impairments faced by the ecosystem due to the continuous employment of inorganic fertilizers.
- One of the crucial constrains in the production of bio-fertilizers is the unavailability of suitable strains, based on the fact that selected strains have the ability to survive both in broth and inoculants carrier.
- Unavailability of suitable carrier is also a chief limitation as if suitable carrier (peat, lignite, charcoal, farmyard manure, soil, rice bran etc.) is not available; it is troublesome to maintain the shelf life of microbial inoculants.
- Inadequate or unskilled human resources and inexperienced staff members are not conscious enough about the proper instruction regarding application.
- Environmental constraints like soil salinity, alkalinity, acidity, drought, flood or water logging affect the proper utilization of bio-fertilizers.
- Short shelf life, susceptibility to high temperature, problem in transportation and storage are some other important bottlenecks that still need to be solved in order to obtain effective inoculation.
- Bio-fertilizers are slow release; crop, soil and strain specific; lesser efficient than synthetic fertilizers and lesser responsive.

Types of Bio-Fertilizer

- Symbiotic nitrogen fixing bacteria: *Rhizobium* is the most significant symbiotic nitrogen fixing bacteria which work by fixing atmospheric nitrogen and converting them into plant available forms in soil and root nodules of legumes. The bacteria seek shelter and obtain food from plants and in return, they help by providing fixed nitrogen to the plants.
- Loose association of nitrogen fixing bacteria: *Azospirillum* is an important example in this regards that lives around the roots of higher plants but do not develop an intimate relationship with plants and this process is often termed as associative mutualism.
- Symbiotic nitrogen fixing Cyanobacteria: Blue Green algae or Cyanobacteria form the symbiotic relationship with various plants. *Anabaena* is found at the leaf cavities of the fern, *Azolla*.
- Free living nitrogen fixing bacteria: They are saprotrophic anaerobes such as *Clostridium*, *Beijerinckia*, and *Azotobacter* etc.

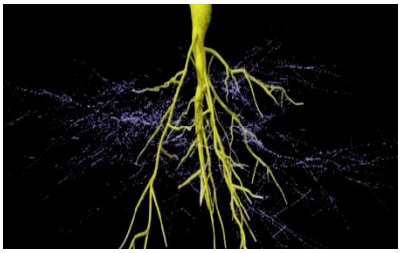

Nitrogen fixation


Rhizobium


Azotobacter


Azolla


Bacillus subtilis


Mycorrhiza

- Phosphate solubilizing bio-fertilizer (PSB): *Bacillus* sp., *Pseudomonas* sp., *Aspergillus* sp. etc. work by solubilizing the insoluble forms of phosphate in soil into soluble or plant usable forms by secreting organic acids which lower the soil pH and cause the dissolution of bound phosphate making them available to the plants.
- Phosphate mobilizing bio-fertilizers (PMB): Mycorrhiza works by scavenging phosphates from soil layers and mobilizing the insoluble phosphorus in soil and these are broad spectrum bio-fertilizers.
- Plant growth promoting bio-fertilizer (PGPB): *Pseudomonas* sp. is the example which works by producing hormones and anti-metabolites for promoting root growth, decomposition of organic matter to help mineralization thereby enhancing the availability of nutrients and improving crop yield.
- Potassium solubilizing bio-fertilizer (KSB): *Bacillus* sp. and *Aspergillus niger* also act as broad spectrum potassium solubilizing microorganisms which solubilise silicates by producing organic acids causing the decomposition of silicates and help to remove the metal ions thereby making them accessible to the plants.
- Potassium mobilizing bio-fertilizer (KMB): *Bacillus* sp. and *Aspergillus* sp. mobilize the inaccessible forms of potassium/silicates in soil along with solubilizing soil phosphorus.
- Sulphur oxidizing bio-fertilizer (SOB): *Thiobacillus* sp. is the most vital one which works by oxidizing sulphur to sulphates, usable by the plants.

Different microorganisms used for production of Bio-Fertilizers (Source: Ritika and Uptal, 2014)

1.Nitrogen fixing Bio-Fertilizers
- Free-living: *Azotobacter, Beijerinckia, Clostridium, Klebsiella, Anabaena,* and *Nostoc*
- Symbiotic: *Rhizobium, Frankia, Anabaena, Azolla*
- Associative symbiotic: *Azospirillum*

2.Phosphate solubilizing Bio-Fertilizers
- Bacteria: *Bacillus megaterium var. phosphaticum, Bacillus subtilis, Bacillus circulans*
- Fungi: *Penicillium* sp., *Aspergillus awamori*

3.Phosphate mobilizing Bio-Fertilizers
- Arbuscular mycorrhiza: *Glomus* sp., *Gigaspora* sp., *Acaulospora* sp., *Scutellospora* sp. and *Sclerocystis* sp.
- Ecto-mycorrhiza: *Laccaria* sp., *Pisolithus* sp., *Boletus* sp. and *Amanita* sp.
- Ericoid mycorrhiza*: Pezizella ericae*
- Orchid mycorrhiza*: Rhizoctonia solani*

4.Bio-fertilizers for Micronutrients
- Silicate and zinc solubilisers*: Bacillus* sp.

5.Plant growth promoting Rhizobacteria
- *Pseudomonas fluorescens*

Caution in the use of Bio-Fertilizers
- Never mix bio-fertilizers with nitrogenous fertilizers.
- Never apply them with fungicides.
- Never expose microbial inoculants to sunlight directly.
- Bio-fertilizers should be stored at room temperature, not below 0°C and above 35°C.
- Do not keep used solution overnight.

CONCLUSION

Our over reliance upon synthetic chemicals has promoted the survival of industries that are producing life threatening hazardous substances for living organisms as well as endangering the ecological counterbalance. Indeed, attentiveness is now-a-days switching from consuming conventionally cultivated food with inorganic chemicals towards food produced in a safe way with the employment of organic products. In this context, bio-fertilizers can solve the obstacle of food requirement for burgeoning global population meticulously and it is very much essential to accomplish the beneficial aspects of bio-fertilizers to administer them in modern agricultural

practices. The application of potential biological fertilizers may play a fundamental responsibility in enhancing crop productivity as well as maintaining the sustainability of natural resource base along with safeguarding the environment, thereby ensuring the sustainability of farming. The modern practice of engaging molecular biotechnology would improve the biological pathways of producing different phytohormones if identified and transferred to the useful plant growth promoting Rhizobacteria which might provide relief from rigorous environmental stresses.

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