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Role of Biofertilizers towards Sustainable Agriculture

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Abstract

Plant nutrients are important for the healthy and nutritious food production. However, after the green revolution, India become self sufficient in foodgrain production by the use of high yielding varieties and higher dose of chemical inputs. This also resulted in some consequences like deprivating the soil's of essential plant nutrients and organic matter which over the time caused a serious threat to human health and the environment resources. This has also led to the depletion of important microflora and fauna which resulted in degrading the soil fertility. To overcome these losses, Biofertilizers prove to be economically viable, eco-friendly, more efficient, productive, and accessible alternatives for small andmarginal farmers over chemical fertilizers. Biofertilizers will act as a substitute for chemical fertilizers in case of increasing soil fertility, controlling diseases and pests, and enhancing crop production under sustainable farming. Use of biofertilizers cause an increment in water uptake, nutrient uptake, growth of plants, and tolerance of plants towards abiotic and biotic stresses. They fix free atmospheric nitrogen, mobilizing fixed nutrients in the soil into forms desired to plants. Thus, they play aneminent role in lifting productivity along with maintaining soil health and sustainability in an eco-friendly and cost-effective way.

Keywords: Biofertilizers, Fertility, Eco-friendly, Sustainability and micro organism

Introduction

Soil is a dynamic living body and contains enormous numbers of diverse living organisms. Organic agricultural practices aim to enhance biodiversity, biological cycles and soil biological activity so as to achieve optimal natural systems that are socially, ecologically and economically sustainable. Biofertilizers are mainly living cells or latent cells of effective and efficient strains of microorganisms that help crop plants in uptake of nutrients when applied through seed or soil because of their interactions in the soil horizons. They escalate various microbial processes inthe soil which in turn augment the extent of availability of nutrients in a form easily assimilated inplants. Applications of biofertilizers is a very crucial component of integrated nutrient management and organic farming because of their cost-effectiveness and renewable source of plant nutrients. Bio-fertilizers initially came into existence by a Dutch scientist in 1888 there after bio-fertilizer use started with the launch of Nitragin by Nobe and Hiltner with a laboratory culture of Rhizobia in 1895 (Ghosh, 2004). Then subsequently Azotobacter, Blue green algae, Azospirillum, Vesicular Arbuscular Mycorrizae, etc. were discovered. They plays potential role in evolving judicious combinations with chemical fertilizers to further supplement the nutrient requirements of crop (Nyekha *et al.* 2015). The various microorganisms and their association with crop plants are currently being exploited in the biofertilizer production.The biofertilizers can be grouped in different ways based on their function, nature and mode of action.

Different Types of Biofertilizers

Rhizobium*:* Rhizobium is the symbiotic bacteria that fix atmospheric N_2 gas in plant through root nodules and have a mutually helpful relationship with their host plants. The plant roots supply essential minerals and newly synthesized substances to the bacteria. Rhizobium is considered the most efficient biofertilizer because of a higher amount of nitrogen fixation. Rhizobium is characterized in seven genera which are highly specific in forming root nodules in legume plants and crops. It was revealed that rhizobium can fix 50-300 kg N/ha. A strain of Rhizobia that nodulates and fixes a large amount of nitrogen in association with one legume species may also do the same in association with certain other legume species.

Azotobacter: Azotobacter are free living and non-symbiotic nitrogen fixing organism that also produces certain substances which are considered good for the growth of plants. The population of Azotobacter is generally low in the rhizosphere of the crop plants and in uncultivated soils. The Azotobacter mostly colonise crop plants such as rice, maize, sugarcane, bajra, vegetables and plantation crops They are considered to be dominantly inhabite the arable soils and have capacity to fix 2-15 mg N_2 fixed /g of carbon source) in culture media.

Azospirillum: Azospirillium is a nitrogen-fixing microorganism beneficial for non-leguminous plants. Azospirillum transcend nitrogen enrichment through production of growth promoting substances. Two species of Azospirillum i.e. Azospirillum lipoferum and A. brasilense are primary inhabitants in soil horizons. Bacteria of Genus Azospirillum are capable of N_2 fixation and can be isolated from the above-ground parts and root of various crop and plant species. They have a Vibrio or Spirillum shape and are Gram-negative bacteria with an abundant accumulation of polybetahydroxybutyrate (70 %) in the cytoplasm of their cells.Along with nitrogen fixation, they performvarious beneficial functions that are growth-promoting substance production (IAA), inducing disease resistance, and drought tolerance.

Azolla: *Azolla* is a free-floating water fern/pteridophyte which passively floats in water and fixes atmospheric nitrogen with nitrogen-fixing blue-green alga *Anabaena azollae* association. The rice-growing areas in South East Asia observed the increase in the application of *Azolla* fern either as an alternate nitrogen source or as a supplement to commercial chemical-based nitrogen fertilizers. *Azolla* is known to contribute 40-60 kg N/ha per rice crop and it is used as biofertilizer mainly in wetland rice production.

Phosphate Solubilizing Microorganisms (PSM): Many soil microorganisms secrete organic acids and lower the pH in their vicinity which leads to the dissolution of bound phosphates in soil horizons, notably species of *Pseudomonas, Bacillus, Penicillium, Aspergillus, etc*. helps to ehance this process. PSB's increase the surface area of the plant roots by increasing the availability of the nutrients in the soil to the plants, assisting the N_2 fixation and enhancing the other beneficial effects of symbiotically. PSB solubilise phosphate by production of organic acids. These acids can either dissolve the phosphorus directly by lowering the pH of soil which can help in ion exchange of PO_4^{2-} by acid ions or they can chelate heavy metal ions such as calcium, aluminium, iron and release associated phosphorus with them. They also increase the soil fertility and productivity of the crops.

Arbuscular Mycorrhizal Fungi (AM Fungi): Mycorrhizae are mutually beneficial (symbiotic) relationships between fungi and plant roots. VAM fungi infect and spread inside the root. These fungi helps in the transfer of various nutrients from the soil to the cells of the root cortex like phosphorus, zinc, and sulfur.This function is mediated by intracellular obligate fungal endosymbionts of the genera *Glomus*, *Gigaspora*, *Acaulospora*, *Sclerocysts*,and *Endogone*.These fungi possess vesicles for the storage of nutrients and arbuscles for funneling and transport of these nutrients into the root system of plants (Rana *et al*. 2013). They are beneficial to crop and are capable of enhancing crop growth by colonizing the roots of the plants. Plant growth promoting rhizobacteria or nodule promoting bacteria are associated with rhizosphere of the soil and enhance the yield by providing the nutrients to the crop plats.

Liquid Biofertilizers: Liquid biofertilizers which contains living or dormant microbes (bacteria, fungi, algae, actinomycetes etc.) alone or in combination which help in fixing atmospheric nitrogen or solubilizers of different soil nutrients as well as the secretion of growth promoting substances for enhancing crop growth and yield.

Need of bio-fertilizers: Indiscriminate use of synthetic fertilizers has led to the pollution and contamination of the soil, has polluted water basins, destroyed micro-organisms and friendly insects, making the crop more prone to diseases and reduced soil fertility. Demand is much higher than the availability. Depleting feedstock/fossil fuels (energy crisis) and increasing cost of fertilizers. Depleting soil fertility is due to widening gap between nutrient removal and supplies. Besides above facts, the long term use of bio-fertilizers is economical, eco-friendly, more efficient, productive and accessible to marginal and small farmers over chemical fertilizers

BiofertilizerApplication Methodology

There are the ways of using Liquid Bio-fertilizers

Seed treatment

Root dipping

Soil application

Seed Treatment: Treating seeds is the common most method among all available methods for all types of bio inoculants. Treatment of seed is generally done with inoculants like *Rhizobium*, *Azotobacter*, *Azospirillum* along with PSM. There is no side/ antagonistic effect if the seed is treated with any two or more than two bacteria. The seeds must be coated first with *Rhizobium*, *Azotobacter*,or *Azospirillum*. After primary inoculation with the above bacteria, PSM inoculant is coated as a secondary or outer layer. This method provides the maximum number of bacteria required for better growth and development of crops (Rao, 2008).

Root Dipping: The root dipping method is used for the application of *Azospirillum*/PSM on paddy crops and in vegetable crops that are transplanted. Culture of*Azospirillum*/PSM is mixed with 5-10 liters of water at one corner of the field in a container and the roots of seedlings are dipped for a minimum of half-an-hour before transplanting of the paddy or various transplanted vegetable crops (Ratti *et al*. 2001).

Soil Application: For the soil application, 200ml of PSM per acre is used.PSM is mixed with 400-600 kg of Cow dung farmyard manure and if available, ½ bag of rock phosphate. The mixture thus prepared (PSM, cow dung, and rock phosphate)is usually kept under any tree or shade overnight and maintaininga 50% moisture level. The mixture as soil application is used in rows or during the leveling of soil.

Foliar Application: Liquid biofertilizer can be applied through fertigation as well as foliar application to the suitable crop. It can also applied through seed treatment and root dipping.

Benefits of bio-fertilizers

Improved nutrient uptake (macro and micronutrients): biofertilizers helps in the improvement of Nitrogen and Phosphorus nutrition of plants It is also reported that the AM-fungi also increases the uptake of K and efficiency of micronutrients like Zn, Cu, Fe etc. By secreting the enzymes, organic acids can makes fixed macro and micronutrients mobile and as such are available for the plant.

Better water relation and drought tolerance: biofertilizers play an important role in the water economy in the plants. Their association improves the hydraulic conductivity of the root at lower soil water potentials and helps in better uptake of water by plants.

Improved Soil structure: Biofertilizers contributes to soil structure by growth of rhizobia or external hyphae into the soil to create a skeletal structure that holds soil particles together ad helps in directly tapping carbon resources of the plant to the soils.

Enhanced phytohormone activity: The activity of phytohormones like cytokinin and indole acetic acid (IAA) is significantly higher in plants inoculated with AM Fungi or Rhizobium. Higher hormone production results in better growth and development of the plant (Wani *et al*. 2002).

Crop protection (interaction with soil pathogens): Biofrtilizers inoculation considerably increases production and activity of phenolic and phytoalexin compounds due to which the defense mechanism of plant becomes stronger there by imparts the resistance to plants.

Constraints in technological aspects

- Due to a lack of availability of proper strains, there is the use of improper, less efficient strains for bio inoculant production.
- There is a lack of knowledge and a lack of qualified technical personnel in production units.
- Unavailability of good quality carrier material or use of different carrier materials bydifferent producers without knowing the quality of the materials.
- Due to a lack of knowledge of basic microbiological techniques, there is the production of poor-quality inoculants and also short shelf life of inoculants.

Conclusion

It can be concluded that biofertilizer is an organic product containing a specific micro-organism in concentrated form which is derived either from the plant roots or from the soil of root zone (Rhizosphere). They helps to improve and maintain the productivity of agricultural lands by supplyingthe essential nutrient and their crop availability.They are of environment friendly non-bulky and low cost agricultural inputs which will increase the productivity, and sustainability at both ecological and farmer's level.

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