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BIOFERTILIZERS

Need of the hour

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Introduction

Bio-fertilizer is a substance which contains living microorganisms whose application to the soil, a seed or plant surface colonizes the rhizosphere and promotes growth by increasing the supply or availability of nutrients to the host plant. Biofertilizers are widely used to accelerate microbial to enhance the availability of nutrients that can be absorbed by the plants easily. They can increase the soil fertility either by fixing atmospheric N_2 or solubilizing insoluble phosphates in the soil, thus leading to an increase in the production of plant growth-promoting chemicals. These substances make use of the naturally available biological system for nutrient mobilization which greatly enhances soil fertility leading to enhanced crop productivity.

In addition to improvement in soil fertility and crop yield, biofertilizers also protect the plants against pests and diseases. They have been found to enhance seedling survival, extend the root system's life, eliminate harmful chemicals, and shorten flowering time. By boosting the nutrient supply, increasing root volume or root area, and enhancing the plant's ability to absorb nutrients, biofertilizers can enhance growth when applied to seeds, plant surfaces, or soil. By populating the rhizosphere and making the nutrients freely available to plant root hairs, biofertilizers, which include a range of bacteria, can improve plant nutrient absorption.

Biofertilizers: Types and Features

Biofertilizers are eco-friendly alternatives to chemical fertilizers that can be classified based on the type of microorganism involved:

1. **Bacterial Biofertilizers:** *Examples*- Rhizobium, *Azospirillum,* Phosphobacteria.

Role: These bacteria play pivotal roles in nitrogen fixation (Rhizobium), nutrient solubilization, and plant growth promotion.

2. **Fungal Biofertilizers:** *Example-* Mycorrhiza
   Role: Mycorrhizal fungi form symbiotic associations with plant roots, enhancing nutrient uptake, especially phosphorus.
3. **Algal Biofertilizers:** *Examples-* Blue-Green Algae (BGA) like Azolla
   Role: Blue-Green Algae fix atmospheric nitrogen and contribute to soil fertility. They can be effectively multiplied in the field
4. **Actinomycetes Biofertilizers:** *Example-* Frankia.
   Role: Actinomycetes, like Frankia, aid in nitrogen fixation and organic matter decomposition

How do Biofertilizers work?

Beneficial microbes enhance the growth of plants either directly or indirectly.

Direct methods include nitrogen fixation; phosphorus, potassium, and zinc solubilization; siderophore production; production of phytohormones; and enzyme and vitamin production. These actions incite morpho- and physiological changes in plants, thus promoting plant growth.

Biological nitrogen fixation: Microorganisms play a crucial part in boosting plant growth by increasing the uptake of minerals from the rhizosphere to other plant parts. Among several other nutrients, nitrogen is an essential nutrient necessary for the growth and maintaining plant productivity. It is a key component of amino acids, nucleotides, and mineral nutrients. However, it is a main limiting nutrient too for the growth of plant as it is mostly present in an inaccessible form (N_2), which both flora and fauna cannot use thus leading to its deficiency. However, some microorganisms have the capability of converting inaccessible form of nitrogen into accessible form to overcome its deficiency. These microbes are called biological nitrogen-fixing bacteria, and the process is called biological nitrogen fixation (BNF). N_2-fixing microbes can fix about 180×10^6 metric tons per year of atmospheric nitrogen by utilizing energy in the form of ATP and convert it into nitrite, nitrate, and ammonia that can be easily consumed by the plants. SNF is a mutualistic relation among plants as well as microorganisms and contributes to the maximum part of fixed nitrogen, while the rest of the portion of the above given estimate is fixed by free-living microbes.

Phosphorus solubilization: Phosphorous is an important and vital element for growth and development of plant. It is a second macro element which is usually restraining the growth of land plants. It plays a dynamic part in plant metabolism, synthesis of proteins, and photosynthetic process. In earth phosphorous exists in organic or inorganic forms (rock phosphate, mineral salts, and calcium phosphate) which plants cannot utilize. However, plants are able to absorb phosphorous in monobasic (HPO_4^-) and dibasic ($H_2PO_4^-$) soluble forms. These microbes convert the organic and inorganic forms of phosphorous into the soluble form.

Production of Siderophore: A plant needs iron for proper growth and development. Iron is used as a cofactor for proteins that are the important part of metabolic processes such as respiration and photosynthesis. Our earth contains an ample amount of iron, but maximum portion of that is present in ferric ionic form which living beings cannot easily assimilate Siderophores are tiny peptide molecules having side chains and functional groups. These functional groups offer ligands with high affnity to which ferric ions can bind. Large number of microbes has been reported that are involved in the production of siderophore. Thus, microorganisms are the key asset that provide plants the required quantity of iron through siderophore production and overcome the defciency of iron through solubilization.

***Phytohormone Production*:** Phytohormones or plant hormones are signal molecules made within plants in a very low quantity. Phytohormones are chemical molecules that promote growth, development, differentiation of cells, and various other functions at very low concentrations. They are directly involved in regular functioning of plants and also execute various other functions indirectly like providing defence against pathogens, abiotic stresses such as salt stress, temperature, and drought.

***Production of Enzymes*:** Plants have numerous enzymes that regulate diverse metabolic activities. Some enzymes itself act as signal molecules such as hydrogen peroxide, regulate cell cycle and photosynthesis, and provide resistance against environmental stresses in plants.

Indirect Methods Indirect action refers to the capability of biofertilizers to diminish the harmful effects of phytopathogens on crop growth and productivity. The indirect methods include antibiotic synthesis, hydrogen cyanide synthesis, induced systemic resistance, cell wall degrading enzymes.

Advantages of Biofertilizers

Biofertilizers are organic in nature and possess secondary metabolites of microbial origin or microorganisms itself. Microorganisms and microbial metabolites ease the release of complex minerals of soil to a simpler form which acts as growth stimulant for a specific crop. By boosting the nutrient supply, increasing root volume or root area, and enhancing the plant's ability to absorb nutrients, biofertilizers can enhance growth when applied to seeds, plant surfaces, or soil.

Constraints of Biofertilizers

1. ***Specific Crop and Soil Compatibility***: Biofertilizers are not universally applicable. Certain strains of biofertilizers are tailored to specific crops and soil types, rendering them less effective when used with other plant varieties or in unsuitable soils.
2. ***Limited Nutrient Availability***: Biofertilizers primarily provide nitrogen-fixing and phosphorus-solubilizing bacteria. However, they do not supply the full spectrum of nutrients required by plants, necessitating additional fertilization for other nutrients.
3. ***Environmental Sensitivity***: The effectiveness of biofertilizers is highly contingent on environmental conditions. Factors such as temperature, pH levels, and moisture can impact the survival and activity of beneficial microorganisms within the biofertilizer, potentially reducing their efficacy.
4. ***Shelf Life***: Biofertilizers have a finite shelf life, and their viability diminishes over time. This limitation necessitates careful storage and distribution to ensure their effectiveness when applied.
5. ***Application Method***: Proper application is crucial. Incorrect application methods or timing can compromise the potential benefits of biofertilizers, requiring a precise match between the product, crop, and application approach.
6. ***Quality Control***: Ensuring the quality and purity of biofertilizer products is paramount. Contamination with unwanted microorganisms or low colony counts can diminish their effectiveness.

Conclusion

Biofertilizers are becoming increasingly crucial in modern agriculture due to their potential to enhance soil productivity and sustainability while minimizing environmental impact. These eco-friendly inputs offer a cost-effective alternative for farmers, providing numerous benefits that contribute to the overall health of agricultural ecosystems. By harnessing the power of beneficial microorganisms, biofertilizers can play a pivotal role in enhancing agricultural productivity while protecting the environment by reducing the application and dependence on synthetic fertilizers.