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A Review on Bio Fertilizers for Crop Production and Soil Fertility

Kuldeep Mishra, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email id- mishraypikuldeep@gmail.com

ABSTRACT: Agriculture is critical to a country's development and existence, thus preserving its quantity and quality is critical for feeding the people and exporting goods. Pesticides and chemical fertilizers are used in modern agriculture with the goal of boosting global food production. As a result, they act as a quick source of nutrition for plants, enabling them to develop more quickly and effectively. Fertilizers, although necessary as a nutritional supplement for plants and mostly composed of nitrogen (N), potassium (K), and phosphorous (P), can pose a number of health risks. Researchers have discovered that "bio fertilizer" is a great alternative to chemical fertilizers that supply nutrients through nitrogen fixation, phosphorus solubilization, and plant development by the production of growth stimulating essence. Based on relevant literature and research work conducted by many researchers, the study examines these constantly available and environmentally friendly nutrients, kinds, and their potential for crop development.

KEYWORDS: Agriculture, Benefits, Bio-Fertilizer, Crop Production, Nutrients.

1. INTRODUCTION

Agriculture has experienced numerous scientific advancements throughout the years in order to become more efficient. Pesticides and chemical fertilizers are used in modern agriculture with the goal of boosting global food supply since they act as a fast meal for plants, enabling them to grow more quickly and effectively. Continuous chemical fertilization degrades soil quality and fertility, and it may lead to heavy metal accumulation in plant tissues, lowering the nutritional value and edibility of the fruit.

As a result, several organic fertilizers that serve as natural stimulators for plant development have been developed in recent years. 'Biofertilizers' are a kind of organic fertilizer that contains results based on plant growth-promoting microorganisms. These biofertilizers were made up of nitrogen-fixing or phosphate-solubilizing microorganisms that worked efficiently. In light of the increasing demand for safe and nutritious food, long-term sustainability, and the problem of environmental contamination linked with the indiscriminate use of agrochemicals, organic farming has emerged as a major concern area across the world [1], [2].

Biological fertilization uses organic inputs such as fertilizers, organic wastes, household sewage, animal manure, and microorganisms like fungus and bacteria. They are used to improve rhizosphere nutrient fixation, produce growth stimulant plants, improve soil stability, provide biological control, biodegrade substances, recycle nutrients, support mycorrhiza symbiosis, and evolve bioremediation processes in soils contaminated with toxic, xenobiotic, and recalcitrant substances. Bio-fertilizers improve production per area in a relatively short period of time, use less energy, decrease soil and water pollution, raise soil fertility, and promote phyto-pathogenic organism antagonism and biological control.

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1.1. Dietary Needs of Plants:

Nutrition is a requirement for growing crops and producing nutritious food for the world's growing population. Plant nutrients are an important component of long-term agriculture. Soils have natural stores of plant nutrients, but only a small part of these reserves is accessible to plants each year due to biological activity or chemical reactions. This release is too slow to compensate for the nutrients removed by agricultural output and to satisfy crop demand. The 16 necessary plant nutrients (macronutrients N, P, K, Ca, Mg, and S; micronutrients Fe, Zn, Cu, Mo, Mn, B, and Cl) in needed amounts to produce optimum yield in crop production are well-established [3], [4].

All macro and micronutrients should be present in a rich soil since these minerals aid plant nourishment. Fertility is essential for plant development, therefore fertilizer and manure application is a required graining activity. For optimal plant development, adequate nutrient levels in the soil must be maintained. Chemical fertilizers alone do not provide all of the nutrients in the balanced amounts that plants need. As a consequence, the organic matter content of the soil decreases, affecting the biological activities and physical characteristics of the soil. All of these factors have sparked considerable interest in the use of biological manures. The use of biological manure not only helps to sustain crop yields, but it also has a direct and indirect impact on nutrient accessibility in soil by improving the physical, chemical, and biological behavior of the soil, as well as increasing the efficiency of applied fertilizers. The kind of fertilizer used to supply vital nutrients for plants has a big impact on crop production. Nutrients must be accessible in sufficient and balanced amounts for optimum plant development. Only a tiny percentage of the soil nutrients is released each year by biological or chemical processes. As a result, fertilizers are created to supplement the nutrients that are already present in the soil.

1.2. Biofertilizers

Chemical pesticides and fertilizers have played an important role in agricultural productivity for a long time. Despite having a little history in contemporary agriculture, their rapid action and cheap cost propelled them to the forefront of public attention. As a result, their negative impacts on the environment, plants, animals, and human life have shifted the focus away from environmentally beneficial plant preservation. The phrase "bio fertilizer" encompasses a wide range of products, including manures and plant extracts.

The term "bio fertilizer" refers to a substance that includes live microorganisms. They stimulate plant development by boosting the availability of primary nutrients to the host plant when applied to plant surfaces. Natural processes such as nitrogen fixation, phosphorus solubilization, and plant growth stimulation, as well as the production of growth-promoting compounds, are used to add nutrients to bio-fertilizers. Bio-fertilizer is technically alive, and it may benefit plant roots in a mutually beneficial relationship. Microorganisms involved in the process might readily transform complex organic material into simpler molecules that plants could absorb. It preserves the soil's natural environment. Growth is increased by 20-30%, artificial nitrogen and phosphorus are substituted by 25%, and plant growth is enhanced. It may provide resistance to drought and certain soil-borne illnesses. Bio fertilizers are live, ready-to-use compositions of beneficial microorganisms that, when applied to seed, root, or soil, increase the microorganisms' availability and usefulness, improving soil health [5]–[7].

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Chemical fertilizers alone do not supply all of the necessary nutrients required by plants, resulting in a decrease in soil organic content, which has a negative impact on the soil's biological and physical characteristics. All of these reasons have contributed to a rise in interest in the use of organic manures in general. Organic manure management not only affects crop yields, but it also has a direct and indirect impact on nutrient accessibility in soil by enhancing the physical, chemical, and biological characteristics of soil, as well as increasing the efficiency of applied fertilizers.

The increasing significance of bio-fertilizers will decrease the need for chemical fertilizers, which will aid in environmental regeneration. Biofertilizer is an organic by-product that is made up of live microorganisms that have been captured from plant roots or soil. Bio-fertilizers are increasingly being used to replace chemical fertilizers in order to reduce crop production costs, improve crop development, and increase crop yield by boosting nitrogen availability and generating specific chemicals that aid plant growth, such as auxin, cytokinin, and gibberellins. Microbial activity is important in agriculture because it affects the mobility and availability of minerals needed for plant development, which reduces the need for artificial fertilizers.

Plant growth is known to be enhanced by the availability of plant nutrients, and bio-fertilizers containing beneficial microorganisms instead of synthetic chemicals may assist to maintain environmental health and soil production. Furthermore, the application of bio-fertilizers may improve production per unit area in a short period of time, consume less energy, decrease soil and water pollution, increase soil fertility, and promote phyto-pathogenic organism antagonism and biological control. Bio fertilizers are important not only for reducing the amount of chemical fertilizers used, but also for increasing the output of sustainable agriculture. Bio fertilizer manufacturing is low-cost and does not pollute the environment. N. V. Joshi began a comprehensive research of biofertilizers in India in 1920. Rhizobium was the first bacterium to be isolated from different farmed legumes, and Gangulee, Sarkaria, and Madhok conducted extensive study on the physiology of the nodule bacteria, as well as its inoculation for improved crop productivity. Traditional bio fertilizers include Rhizobium and Blue Green Algae (BGA), whereas Azolla, Azospirillum, and Azotobacter are in the middle.

1.2.1. Nitrogen Fixation by Living Organisms:

The German scientists Hellriegel and Wilfarth were the first to recognize nitrogen fixation in 1886, when they discovered that legumes with root nodules could utilize gaseous nitrogen. In 1888, a Dutch scientist named Beijerinck succeeded in isolating a bacterial strain from root nodules. This strain of Rhizobium leguminosarum was isolated. According to Stewart (1969), the microbiologists Beijerinck and Lipman identified Azotobacter spp. in 1901 and 1903, respectively, while Winodgradsky (1901) isolated the first strain of Clostridium pasteurianum. Later, nitrogen fixing in blue-green algae was discovered to be innovative. Currently, study efforts in these areas have shown a number of positive characteristics.

Protein, nucleic acids, and chlorophyll all include nitrogen. As a result, the quantity of protein, amino acids, protoplasm, and chlorophyll produced will be affected by nitrogen availability to the plant. As a result, a steady supply of nitrogen is required to produce high crop yields. Although nitrogen makes approximately 78 percent of the atmosphere, it is in an inaccessible state for organisms to utilize. There are 80,000 tons of distant nitrogen in every hectare of land. To make it usable, it must be fixed either via an industrial method or by biological nitrogen fixation (BNF).

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The absence of these nitrogen-fixers makes life tough on this planet. Nitrogen (N) shortage is often cited as a major constraint on crop productivity. It's a crucial plant nutrient that's often used as a nitrogen fertilizer to boost the production of agriculturally essential crops. Treatment of Plant Growth-Promoting Bacteria may be an interesting option to reducing the usage of N-fertilizers.

In crop management, efficient 'Nitrogen' use is critical. Modern agricultural sciences have given us biofertilizers, which delay nitrification for a longer period of time and improve soil fertility. Biofertilizers are an important part of an integrated nutrient management strategy. As a result, it would play an important role in soil productivity and sustainability while also preserving the environment. It would also be a lucrative, environmentally friendly, and replaceable source of plant nutrients to complement chemical fertilizers in a long-term agricultural system. Biofertilizers, unlike inorganic fertilizers, do not provide nutrients to plants directly. These are microbial inoculants that contain the living cells of effective strains and are used to inoculate seeds, soil, or composting areas with the goal of encouraging the microbial process to increase the availability of nutrients that are easily absorbed by plants, capture the interior of the plant, and encourage growth by converting nutritionally essential elements to convenient form through biotransformation. Biofertilizers include beneficial microorganisms that help plants develop and protect them from pests and illnesses. Biofertilizers are grown to take advantage of the natural, organic mechanism of nutrient mobilization. Nitrogen-fixing microorganisms and phosphorus-solubilizing microorganisms are the two most prevalent kinds of bio-fertilizers used today.

1.2.2. Plant growth promoting rhizobacteria (PGPR):

Differential bacterial taxa are important soil components. Rhizobacteria that promotes plant growth. Rhizobacteria that promote plant development have the capacity to fix atmospheric nitrogen and produce metabolites such as auxin, cytokinin, gibberellins, hydrogen cyanide (HCN), phytohormones, and unstable compounds. PGPR also generates mineral dissolving chemicals, such as phosphorus solubilization, as well as internal resistances. Azotobacter has the capacity to generate chemicals like Indole acetic acid (IAA), Gibberellins, vitamin B complex, and growth boosting hormones, all of which have the potential to boost plant growth and output. The use of nitrogen-fixing bacteria in non-legume crops has resulted in significant improvements in plant growth. The synthesis of growth-promoting chemicals like IAA and Gibberellic acid, as well as biological nitrogen fixation, may explain the increase in plant growth. Plant growth boosting rhizobacteria are bacteria that encourage plant development [8].

1.2.3. Rhizobium:

Rhizobium is a member of the Rhizobiaceae family. They are Gram-negative, motile, non-sporulating rod-shaped free-living organisms found in soil that have a symbiotic ability to fix atmospheric nitrogen. They are an endosymbiotic N-fixing bacteria associated with legume roots. It enters plants via the root system and produces nodules later. The energy needed for N fixation in root nodules is obtained from the host by reacting with the available H molecules and forming NH_3. Rhizobium uses the carbohydrates generated by legume plants as the sole source of hydrogen in the conversion of nitrogen to ammonia. As a result, the root nodules serve as a micro fermentor for organic N fixation, converting atmospheric nitrogen to ammonia. Rhizobium has the ability to affect rice plant shoot and root development. It has a very unique relationship with legume hosts, and it fixes nitrogen in the specific host plant.

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Rhizobium also has host specificity, which is regulated by plant chemicals such as flavonoids generated by the host plant. Rhizobium's nod genes are triggered by flavonoids. It starts with an infection on the root surface, and then the root curls. Rhizobium begins to migrate into the root hair after infection. As a result, the bacterium stops multiplying and forms bacteroids, which fix the N nod and nif genes, which code for the protein nodulin. It contains leg hemoglobin, which is involved in nodule formation, as well as nif genes, which are involved in nitrogen fixation. It contains structural genes for nitrogenase and other regulatory enzymes and is found in both free-living and symbiotic N-fixing bacteria. Rhizobium inoculants may be introduced into soil via a variety of ways, with seed dipping being one of the most popular. The bacterium attacks root hair during seed germination and spreads to the root. Rhizobium will convert N into ammonia for plant development as the plant develops [9].

1.2.4. Cyanobacteria:

Cyanobacteria play an important role in the worldwide nitrogen cycle. Cyanobacteria that fix nitrogen are among the most common and significant nitrogen fixers on the planet. Cyanobacteria, often known as blue green algae, are a diverse group of prokaryotes that establish intricate relationships with bacteria and green algae in cyanobacterial mats. In both freshwater and marine environments, they are the most important nitrogen fixers. Nitrogen-fixing bacteria offer a critical source of nitrogen to the marine environment across vast regions of the world's seas. They also thrive in a variety of terrestrial settings, from rainforests to deserts, where they grow and fix nitrogen. Cyanobacteria can live in harsh conditions because to unique adaptations including the capacity to fix nitrogen and resistance to desiccation. Cyanobacterial mats have been utilized as a bio fertilizer in contemporary agriculture due to its ability to fix atmospheric nitrogen [10].

2. DISCUSSION

Soil microbes are essential in controlling the dynamics of organic matter decomposition and the availability of plant nutrients like N, P, and S. Microbial inoculants are widely acknowledged as an important component of integrated nutrient management, which leads to sensible agriculture. Furthermore, microbial inoculants may be utilized as a cost-effective means of increasing crop production, lowering fertilizer dosages, and harvesting more nutrients from the soil. By preserving fruit output and quality and encouraging nutritionally supplied plants with reduced production costs, biofertilizer may be utilized as a nutrient source for soil microbiology. By turning atmospheric nitrogen into organic forms that are useable by plants, nitrogen-fixing bacteria play a critical role in increasing yield. Rhizobia and legumes are mutually linked, and nitrogen fixation takes place in the bacterium's root or stem nodules. Rhizobium inoculation improves root nodulation, plant development, and grain production by 10-15% under cultivated conditions as compared to a crop that has not been infected. Unique annual legumes have been found to fix 35-270 kg of nitrogen per hectare per year.

Alcaligenes, Azospirillum, Bacillus, Herba spirillum, Klebsiella, Pseudomonas, and Rhizobium are likely candidates for biological N fixing in rice. Rhizobium penetrates the root hairs, multiplies, and produces root nodules because to its resistance to extreme temperatures. Bio fertilizers are primarily made up of chosen live microbe cells that give nutrients to plants through their root systems. Different methods are used by the microorganisms in these fertilizers to deliver nutrients to the plants. They can fix nitrogen, solubilize phosphate, mobilize phosphate, and promote the growth of rhizobacteria. The preparation contains microorganisms that may be beneficial to the

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soil. The packaging's appropriateness is guaranteed for a longer shelf life as well as the environment's and user's safety. Bio fertilizers are growing more popular as a result of their nutritional value and reduced environmental effect. They are also promoted as a renewable resource that may be used to supplement chemical fertilizers. According to many studies, bio-fertilizers have an important role in improving soil fertility, crop production, and ultimate output. Furthermore, their usage in soil improves soil biota while reducing the need of chemical fertilizers. Biofertilizers assist preserve plant health by stimulating nutrients that promote the development of biological processes in soils. This is aided by the provision of balanced nutrients, which offer food and promote the development of microorganisms, as well as the presence of helpful soil worms. Root growth and organic matter in the soil are improved as a result of the excellent structure given to the soil. The use of biofertilizers has a significant impact on micorrhizal growth, which in turn is accountable for the soil's high phosphorus concentration.

3. CONCLUSION

Chemical fertilizers used in modern agriculture have depleted soil fertility, rendering it unsuitable for growing crops. Excessive use of these inputs has also resulted in serious health and environmental risks, including soil erosion, water pollution, pesticide poisoning, a falling groundwater table, water logging, and biodiversity loss. Biofertilizers are soil microorganisms that spontaneously activate in an efficient and environmentally benign manner, acquiring increasing significance for use in agricultural production, restoring soil fertility and protecting it from drought and soil diseases, and therefore stimulating plant development. Soil enrichment is achieved using biofertilizers, which are appropriate for long-term use. They are also non-toxic to the environment and may be used in place of chemical fertilizers.

Bio-fertilizers may reduce the usage of chemical fertilizers, reducing environmental risks, improving soil structure, and promoting agriculture. Biofertilizers are less expensive and have a significant impact on cereal crop production. Bio-fertilizers, which are essential components of organic farming, serve a critical role in ensuring long-term soil fertility and sustainability by converting insoluble P in the soil into plant-available forms, thus boosting its efficacy and availability. Excessive dependence on chemical fertilizers, both in terms of cost and environmental effect, is not a viable approach in the long run owing to the expense, both in terms of domestic resources and foreign currency; engage in the establishment and maintenance of fertilizer facilities. Biofertilizers are an alternate option for meeting crops' nutritional requirements. Beneficial bacteria found in biofertilizers include Azotobacter, Azospirillium, Rhizobium, and Mycorrhizae, all of which are critical in crop development. Plants that use bio fertilizer are more tolerant to environmental stressors.

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