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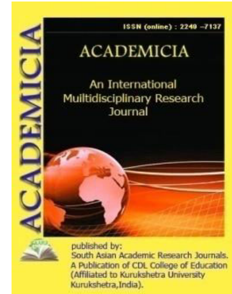

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A BRIEF DESCRIPTION ON BIOFERTILIZERS

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ABSTRACT

The global rise in human population poses a serious danger to each person's food security, since agricultural land is restricted and, in some cases, disappearing. As a result, agricultural production must be substantially increased during the next several decades to satisfy the enormous food demand of the growing population. Not to mention that a heavy reliance on chemical fertilizers for increased output ultimately harms both the environment and human health. Because of its wide potentiality in improving crop productivity and food safety, using microorganisms as biofertilizers is seen as a potential alternative to chemical fertilizers in the agricultural industry. In the agricultural sector, certain microorganisms such as plant growth boosting bacteria, fungus, Cyanobacteria, and others have been found to exhibit biofertilizer-like properties. Extensive research on biofertilizers has shown that they are capable of delivering necessary nutrients to the crop in adequate quantities, resulting in an increase in crop production. The current study elucidates the many methods by which biofertilizers enhance plant development while also providing protection against several plant diseases. The goal of this study is to examine the critical functions and uses of biofertilizers in many industries, such as agriculture, bioremediation, and ecology.

KEYWORDS: *Biofertilizer, Crop Production, Ecosystem, Sustainable Agriculture.*

1. INTRODUCTION

At the moment, the world's population is estimated to be about 7 billion people, with this figure projected to grow to roughly 8 billion by 2020. As the world's population grows, so does the environmental harm caused by fast industrialisation and urbanization. Furthermore, feeding the current huge population, which will surely grow with time, is a major problem. Regardless, the extensive use of chemical fertilizers in agriculture helps the nation self-sufficient in terms of food supply, but it also significantly harms the environment and has negative effects on living creatures[1]–[4]. Chemical fertilizer is used indiscriminately, posing a serious danger to the environment by contaminating the air, water, and soil. Because these dangerous compounds cannot be absorbed by plants, they accumulate in ground water, and some of them are also responsible for eutrophication of water bodies. These compounds have a negative impact on soil in terms of water holding capacity, soil fertility, increased salinity, and nutrient disparity. Organic farming has arisen as a powerful alternative sector in terms of the increasing need for healthy food supply, long-term sustainability, and worries about environmental contamination, given all of the negative consequences of extended usage of chemical fertilizers. Although the use of chemical fertilizers is necessary in order to satisfy the world's growing food demand, organic farming offers possibilities for some crops and specialized regions to thrive.

1.1 Bio-fertilizers:

A biofertilizer is a product that includes live microorganisms that colonize the rhizosphere or inside of plants and stimulate plant development by increasing the availability of nutrients to the host plant when applied to seeds, plants, or soil. Biofertilizers are commonly used to speed up microbial activities that increase the availability of nutrients that plants may readily absorb. They enhance soil fertility by fixing atmospheric nitrogen and solubilizing insoluble phosphates, as well as producing soil-based plant growth promoters.Figure 1 shows use of biofertilizers in plants.

Figure 1: The above diagram shows use of biofertilizers in plants[5]

1.2 Plant growth-promoting bacteria:

Free-living bacteria that establish specialized symbiotic relationships with plants, bacterial endophytes that may colonize at certain parts of plant tissue, and Cyanobacteria are all examples of plant growth-promoting bacteria (PGPB). Despite the fact that each bacterium differs in certain aspects, they all have the same methods for encouraging bacterial development. They may stimulate growth both directly and indirectly by decreasing the inhibitory effects of different pathogenic agents on plant growth and development. Rhizobium, Bradyrhizobium, Sinorhizobium, Azospirillum, Nostoc, Anabaena, Acetobacter, Bacillus megaterium, Azolla, Bacillus polymyxa, and other bacteria that promote crop production and overall plant development are all common plant growthpromoting microorganisms[6].

1.3 Rhizobium:

The Rhizobiaceae (-proteobacteria) family of symbiotic N2-fixing rhizobacteria infect and form a symbiotic connection with the roots of leguminous plants. This involves a complicated interaction between the host and the parasite, which culminates in the development of nodules in which Rhizobia colonize as intracellular symbionts. Rhizobia includes the bacteria Rhizobium, Bradyrhizobium, Sinorhizobium, Azorhizobium, and Mesorhizobium. Diazotrophs are non-symbiontrhizobacteria that fix nitrogen in non-leguminous plants and are capable of establishing a non-obligate relationship with the host plants. The complex enzyme structure nitrogenase, which comprises of dinitrogenasereductase with iron (Fe) as its cofactor and dinitrogenase with iron (Fe) and molybdenum (Mo) as its cofactor, is responsible for nitrogen fixation.

1.4 Azospirillum:

They are gram-negative, aerobic nitrogen-fixing bacteria that do not form nodules and belong to the Spirilaceae family. Although there are numerous species in this genus, such as Azospirillumamazonense, Azospirillumhalopraeferens, and Azospirillumbrasilense, Azospirillumlipoferum and A. brasilense are the most helpful. Because they develop and fix nitrogen on the organic salts of malic and aspartic acid, Azospirillum establishes associative symbiosis with many plants, especially those with the C4 dicarboxylic route (Hatch-Slack pathway) of photosynthesis. As a result, it is mostly suggested for maize, sugarcane, sorghum, pearl millet, and other crops. They generate growth promoters (IAA, gibberellins, and cytokinin) and improve root development and N, P, and K absorption in plants. Inoculation with Azospirillum has a significant impact on root growth and exudation[7].

1.5 Blue-green algae (Cyanobacteria) and Azolla:

They are photographic in nature and belong to eight distinct families. They stimulate plant development by generating auxin, indole acetic acid, and gibberllic acid, and they fix approximately 20–30 kg nitrogen per hectare in submerged rice fields, where they are plentiful[8], [9]. For low-land rice cultivation, nitrogen is one of the most important nutrients in significant amounts. Soil nitrogen and biological nitrogen fixation (BNF) by related microorganisms are the two main sources of nitrogen. Fungi, liverworts, ferns, and flowering plants establish symbiotic relationships with blue-green algae.

1.6 Role of biofertilizer in photosynthesis:

Because almost 90% of plant biomass is generated from CO2 absorption via photosynthesis, higher photosynthesis indicates greater plant development. In comparison to the uninoculated control, biofertilizers R. leguminosarum, Rhizobium sp. IRBG 74, and Bradyrhizobium sp. IRBG 271 enhanced the single-leaf photosynthetic rate of the plant. When compared to the uninoculated control plant, the IRBG strain exhibited the greatest increase in photosynthetic activity (14%) of the three candidates examined. Certain Rhizobia test strains were found to significantly increase the surface, areas of plant leaves, net photosynthetic rate of plants, stomatal conductance, and water utilization efficiency of rice, implying that rhizobial inoculation of rice can significantly increase the plant's photosynthetic capacity. Water stress produces a number of reactive oxygen species, which damages the plant's photosynthetic machinery.

1.7 Effect of biofertilizer in amino acid synthesis:

The rhizosphere is the zone of soil surrounding the root system, and "rhizobacteria" refers to a group of rhizosphere bacteria capable of colonizing the root environment[10]. Plant roots produce and release a broad range of chemicals, including amino acids, in addition to providing mechanical support and enabling water and nutrient absorption. The substances released into the soil by roots are known as "root exudates". Chemical attractants for a large variety of heterogeneous and extremely varied microbial populations are produced by plant roots. Exudation of various chemical compounds changes the physicochemical characteristics of soil, affecting the organization of the soil microbial community in the immediate vicinity of the root surface. The kind of amino acids, as well as the composition of root exudates produced by the plant, is therefore determined by the plant's species and accompanying microbes. As a result, the kind of amino acids secreted by the plant changes greatly depending on the adhering PGPR microbial population.

1.8 Role of biofertilizer in remediation of pesticides:

To prevent or suppress plant diseases, insecticides, fungicides, herbicides, and nematicides are employed. Pesticides are an essential part of contemporary agriculture since they are required for cost-effective pest control. However, since pesticides may readily penetrate into the tissues of living creatures and cause bioaccumulation, they are harmful to the environment and pose a potential danger to the plant kingdom as well as humans. Nonetheless, owing to their eco-friendliness, cost-effectiveness, and possible removal from the environment, bioremediation methods for treating pesticide contamination have gotten a lot of attention. Furthermore, research on pesticide-degrading bacteria strains is developing as a potential alternative for combating pesticides' negative effects. Numerous studies have been conducted on PGPR, emphasizing on its critical function in agriculture, horticulture, forestry, and environmental protection. As a result, a number of studies have been conducted on the function of PGPR in pesticide bioremediation. Microorganisms such as Azospirillum, Azotobacter, Bacillus, Enterobacter, Gordonia, Klebsiella, Paenibacillus, Pseudomonas, Serratia, and others have been found to have the potential to decrease pesticide toxicity.

1.9 Effect of biofertilizers on ecosystem:

Despite the fact that biofertilizers have been extensively employed in agriculture for many decades, information on their colonization and ecology is lacking. Furthermore, the process behind their interactions with plants and the local microbial population continues to pique people's interest. The presence of indigenous microflora in the rhizosphere is one of the main variables that determines the effectiveness of a biofertilizer in a natural system. The biofertilizer's survival and plant growth-promoting qualities may be harmed by this highly competitive population of different organisms in the rhizosphere. Furthermore, bacterization of seeds and seedlings or soil additions may alter the structure of native microflora, which must be taken into account when determining the safety of introducing bacteria into the environment.Finally, the non-target impact of microbial biofertilizers on species other than target pathogens, the influence on biogeochemical cycles, the effect on soil texture, soil characteristics such as water-retaining capacity, porosity, and fertility, and erosion avoidance should all be carefully addressed. As a result, before releasing biofertilizers into the environment, it is critical to assess their non-target impacts on resident microflora populations and, as a result, on ecosystems, as well as a thorough study of the effects of biofertilizers before changing agricultural methods.

1.10 Types of biofertilizer formulation:

Biofertilizers are live microbial cells in a viable condition that are used to improve soil fertility. They are made in such a manner that they are both viable and capable of increasing soil fertility, productivity, and plant development at the same time. The biofertilizers are made in multistep procedures that mix several strains with specific chemicals that preserve the cells during storage. Peat, liquid, granules, and freeze-dried powders are the four main kinds of formulation that have been utilized widely so far.

1.10.1 Peat formulations:

Peat is made up of decomposed plants that have collected over time. It offers a nutrient-rich and safe habitat for a broad variety of microorganisms that may grow and form micro colonies on the surface of particles as well as in cervices. The main characteristics of peat formulation are that it must be nontoxic, extremely adsorptive, and easy to sterilize, have a high organic matter content and water holding capacity, and be readily accessible at a reasonable cost. Peat is an ill-defined and complicated substance made up of many sources with varying capacities for supporting cell development and survival.

1.10.2 Liquid formulations:

Aqueous (broth cultures), mineral or organic oils, oil in water, or polymer-based suspensions are all used in liquid formulations. Liquid biofertilizers have grown in popularity due to their ease of use and application on seedlings or in soil. They usually have high cell concentrations and allow for the application of a less amount for the same effectiveness. Furthermore, unlike solid carrier-based biofertilizers, liquid formulation provides for sufficient quantities of nutrients and cell protectants to enhance performance. Furthermore, as compared to peat-based formulations, they are said to have no contamination, a longer shelf life for certain formulations, better protection against environmental stressors, and improved field effectiveness.

1.10.3 Granules:

Peat prill or tiny marble, calcite, or silica grains are wetted with an adhesive and combined with powder-type inoculums to make granules. The target microorganisms are coated or impregnated into the grains. The size of the granules varies, but there is a clear link between the density of the mother culture population and the quality of the final result. The higher the quality of the mother culture, the higher the quality of the final output.

1.10.4 Freeze-dried powders:

In certain instances, dry biofertilizers made from soil, organic, or inert carriers have been employed.

2. DISCUSSION

Consumer views about the usage of bio fertilisers and food produced acceptability and manufacturing safety for human well-being are quite important. The consequences of chemical fertilisers on the public, the land and the ecosystem are deteriorating. However, development, marketing and their technique of application are under the authority of major businesses and genetic committees. Bio fertilize agro-industrial issues can be solved in a very specific manner. Chemical fertilisers in contemporary farming have decreased soil fertility, rendering it inadequate for the cultivation of crops. Furthermore, these inputs' extensive usage has resulted in serious health and environmental threats such as soil erosion, pollution of the water, pesticide poisoning, decreasing groundwater table, water logging and biodiversity depletion. Bio fertilisers naturally activate the soil's inexpensive, efficient and environmental friendly microorganisms and, as a result, promote plant growth and restore the natural fertility of the soil from drought or soil disease. Further research and development are needed to understand the mechures to act for different biofertilizer and find more competent rhizobacterial strains and carrier materials to make agriculture more sustainable and economical. The success of biofertilizer technology requires further research and development. Farmers should be instructed on the environmental and other major favourable impacts on the farming system of biofertilizers to make them more popular among farmers.

3. CONCLUSION

Environmental stressors are becoming a significant issue, and as a result of their negative impact, agricultural production is decreasing at an unprecedented pace. Because of our over-reliance on chemical fertilizers and pesticides to meet the increasing demand for food, companies have been pushed to develop life-threatening substances as pesticides or fertilizers. These substances are not only harmful to human health, but they also have a negative impact on the environment's ecological equilibrium. In this difficult scenario, biofertilizer may provide a viable alternative that will not only feed the growing population but will also protect agriculture from the effects of different environmental stressors. As a result, it is necessary to comprehend the many essential and advantageous features of biofertilizers, as well as the execution of their use in contemporary agriculture. Extensive study into the development of efficient, temperature-tolerant strains is a must for long-term success in this new sector. The most essential and difficult aspect of the study is that, in addition to identifying different biofertilizer strains and their characteristics, it is also necessary to address the real mechanism of biofertilizers for their effectiveness in sustainable agricultural development.

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