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A Review on Bio-fertilizer and its Role in enhancing Soil Fertility and Crop Productivity

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ABSTRACT: Plant nutrients are necessary for the development of crops and nutritious food for the world's growing population. Today's soil management methods rely mostly on inorganic chemical-based fertilizers, which pose a significant health and environmental risk. In sustainable farming, bio-fertilizer has been discovered as an option for improving soil fertility and crop output. Because of their potential significance in food safety and sustainable crop production, the use of beneficial microorganisms as bio-fertilizers has become more important in the agricultural industry. Bio-fertilizers may be an essential part of a comprehensive nutrient management strategy. Nitrogen fixers (N-fixers), potassium and phosphorus solubilizers, growth promoting rhizobacteria (PGPRs), endo and ecto mycorrhizal fungi, cyanobacteria, and other helpful microscopic organisms are all frequently employed as bio-fertilizer components. Improved nutrient and water absorption, plant development, and plant tolerance to abiotic and biotic influences are all benefits of using bio-fertilizers. As eco-friendly and cost-effective inputs for farmers, these prospective biological fertilizers would play a significant role in soil production and sustainability, as well as in environmental protection.

KEYWORDS: *Agriculture*, ***Biofertilizer, Crop Productivity, Plant, Soil fertility,***

1. INTRODUCTION

Agriculture has progressed significantly since the 12th century, and it is now widely practiced all across the globe. Agriculture employs one-third of the world's workforce, according to statistics from 2007. Agriculture provides a livelihood for 55 percent of Africans, according to the Food and Agricultural Development Organization. Agriculture is the primary source of income for most Nigerians, particularly in rural regions, and we are completely reliant on it for our food. With the recent drop in crude oil prices, which is now Nigeria's primary source of revenue, President Muhammadu Buhari GCFR has stressed that the country must return to agriculture, especially crop cultivation, which was the country's primary source of income prior to the discovery of crude oil. To feed Nigeria's growing population, which is projected to reach 221 million by 2020, extremely rich soils are required for long-term agricultural production, according to the 2006 Nigerian population census [1], [2].

Soil fertility is the most significant restriction limiting agricultural production in developing countries throughout the globe, particularly among resource–poor farmers. As a result, preserving soil quality may help to alleviate issues like land degradation, falling soil fertility, and fast dropping output levels in many areas of the globe where fundamental agricultural concepts are lacking. Low crop production is a common issue in Sub-Saharan Africa's agricultural systems (SSA). Low yields are particularly noticeable in legumes, and they are often linked to decreasing soil fertility and reduced nitrogen fixation as a result of biological and environmental variables. Biological nitrogen fixation (BNF), a major source of nitrogen for farmers who use minimal fertilizer, is one of the possible answers and is important for the long-term production of legumes and even non-legume crops [3], [4].

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Due to increasing population, continual cultivation of the same piece of land year after year has resulted in a decrease in soil fertility to the point that, even with the use of artificial inorganic fertilizer, nothing is gained in return.

Traditional agriculture plays an essential role in supplying the food requirements of an expanding human population, but it has become more reliant on the use of chemical fertilizers and pesticides to boost production. Chemical fertilizers are manufactured compounds containing known amounts of nitrogen, phosphorous, and potassium. As a consequence of eutrophication of water bodies, the use of chemical fertilizers pollutes the air and ground water. The use of chemical fertilizers and pesticides not only increases soil acidification, but it also puts ground water and the atmosphere at danger of contamination. It also weakens plant roots, making them more vulnerable to disease. In this respect, recent efforts have been undertaken to produce nutrient-rich, high-quality fertilizer (Bio-fertilizer) in order to guarantee bio-safety. In sustainable farming, bio-fertilizer has been discovered as an alternative to chemical fertilizer for increasing soil fertility and crop output. As eco-friendly and cost-effective inputs for farmers, these prospective biological fertilizers would play a significant role in soil production and sustainability, as well as protecting the environment. Organic farming is one of these methods that guarantees food safety while also increasing soil biodiversity. The application of bio-fertilizer to the soil promotes biodiversity, which includes a variety of beneficial bacteria and fungi, such as arbuscular mycorrhiza fungi (AMF) and nitrogen fixers known as plant growth promoting rhizobacteria (PGPR). In the soil, particularly in the rhizosphere of plants, there are many microorganisms that thrive. A large number of these microorganisms have a functional connection with plants and form a holistic system. They have a positive impact on the development of plants. Beneficial microorganisms have been used in agricultural operations for nearly 60 years, and it is now clear that these bacteria may improve plant tolerance to unfavorable environmental stressors such as water and nutrient shortage, as well as heavy metal pollution [2], [5].

By nitrogen fixation, phosphate and potassium solubilization or mineralization, release of plant growth regulating chemicals, generation of antibiotics, and biodegradation of organic materials in the soil, bio-fertilizers maintain the soil environment rich in all types of macro and micro nutrients. When treated as seed or soil inoculants, bio-fertilizers grow and participate in nutrient cycling, resulting in increased crop production. In general, 60 percent to 90 percent of the fertilizer applied is wasted, with the remaining 10 percent to 40% taken up by plants. As a result, bio-fertilizers may be an essential part of integrated nutrient management systems for agricultural production and environmental health.

Bio-fertilizers are products that include live cells from various microorganisms that may transform nutritionally essential components from inaccessible to available form through biological processes. The purpose of this review is to examine the role of bio-fertilizers in sustainable agriculture, in order to meet the needs of agriculturists and plant biologists whose work focuses on developing clean and efficient ways to improve soil quality by nourishing and maintaining the useful and natural flora of microorganisms. Furthermore, it discusses current advancements in the area of agricultural management, highlighting the benefits of using bio-fertilizers in terms of better nutrient profiles, plant growth and production, and stress tolerance.

Soil Fertility

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The portion of the ground on which plants grow is referred to as soil. Top soil, sub-soil, and parent material are the three layers. The top soil, on the other hand, is more important since it is the portion that promotes plant development. A productive soil includes minerals, air, water, living organisms, and inorganic and organic materials, all of which must be in a certain ratio with at least a medium pH. A good grade soil contains 45 percent minerals (sand, silt, and clay), 25% water, 25% air, and 5% organic and living stuff. The mineral portion of a soil, which makes up half of its volume, contains about 93 percent silica, aluminum, and iron oxides; 4% calcium, potassium, and magnesium oxides; 3% titanium, sodium, and a very small amount of nitrogen, phosphorous, boron, manganese, zinc, copper, chlorine, molybdenum, and many other elements. However, only fourteen minerals are necessary to plants, and these are known as essential elements.

Nitrogen:

Plants need a lot of nitrogen, which is one of the most important macronutrients. Its functions include the formation of base pairs for RNA and DNA, the formation of phosphate groups in proteins (for example, the hemp group of chlorophyll), and hormones such as cytokines, metal uptake (phytosiderorphores), transport in xylem and phloem (for example, copper with amines), as well as alkaloids, miscobiochemicals such as mescaline and quinine.

Plants absorb nitrogen in the form of nitrates, ammonium, and sometimes urea, which is then supplied to the soil through fertilizer, biological nitrogen fixation, rainfall and thunder, and organic matter decomposition. Stunted growth and pale green or yellow leaves are signs of a nitrogen deficiency in plants. Necrosis, which starts at the tip of the older leaves and develops into a ‘v' pattern, is a sign of severe insufficiency.

Phosphorus:

Phosphorus is required in relatively significant quantities, although in less proportions than nitrogen and potassium. It encourages legume growth and yield, as well as nodule number and mass. Phospholipids in membranes, phosphor proteins for life activities, and agricultural productivity and quality enhancement are some of its roles. It plays an essential role in the development of seeds. It has been discovered that it is a significant component of seeds and fruits. Phosphorus is taken by plants as phosphates and supplied to the soil through fertilizers, bone meal, and superphosphates. Phosphorus deficiency symptoms are uniformly distributed throughout the plant because it is phloem mobile. Its shortage, on the other hand, is often linked to stunted development and late maturity. Grassy plants, such as maize, exhibit reddening of the leaves in extreme instances. Excess phosphorus is bad because plants can't effectively absorb it since the majority of phosphorus is inorganic. Plants that have received too much phosphorus mature early and have a poor crop yield.

Potassium:

This element is only second in importance to plants after nitrogen. Through its effects on water absorption, root development, turgor maintenance, transpiration, and stomatal control, potassium affects the water economy and crop growth. Potassium's functions include the following: It improves certain plants' cold tolerance as well as their resistance to fungal and bacterial infections; it increases the production of high molecular carbohydrates, resulting in stronger cell walls in cereal straw. It helps in photosynthesis, protein synthesis, and enhancing fruit quality by catalyzing the activities of certain enzymes and promoting the production and accumulation of certain vitamins in plants (Thiamin and Riboflavin). It is also required for the function of guard cells.

Plants absorb potassium in the form of potassium ions, which are insoluble in water. Fertilizer, decomposing organic waste, and wood ash all contribute to its presence in the soil. Potassium shortage affects carbohydrate and protein metabolism through disrupting plant metabolism, inhibiting the action of certain enzymes. Inadequate potassium availability also lowers seed viability, making plants more susceptible to diseases, and makes them harder to maintain under marketable conditions when harvested, according to the author. Oxygen, carbon, and hydrogen are three more elements that plants need in significant quantities. These are abundant in nature since they are acquired via air and water.

The combined impact of light, air, water, micro and macro nutrients, and pH has been proven to affect the total yield of crops. However, when the soil is continually farmed, the pace at which nutrients are taken exceeds the rate at which they are supplied, resulting in nutrient depletion. Aside from being taken up by plants, nutrients are lost from the soil in a variety of ways. Leaching, poor irrigation, overtillage, and bush burning are just a few examples. Poor crops are caused by a loss of soil fertility, which may be remedied by using an environmentally friendly bio-fertilizer. To achieve high yields, agrochemicals such as chemical insecticides and chemical inorganic fertilizers have been widely used in recent years. Intensive use of agrochemicals causes a slew of agricultural issues, as well as inadequate farming systems. For several crops, some farmers use higher amounts of chemical fertilizers than are advised. This technique hastens soil acidification while also posing a danger of polluting subterranean water and the atmosphere. It also weakens plant roots, making them more susceptible to disease.

Biofertilizers

A bio-fertilizer is simply a material that includes live microorganisms that colonize the rhizosphere and stimulate development by increasing the supply or availability of nutrients to the host plant when applied to the soil, a seed or plant surface. A bio-fertilizer is a contemporary version of organic fertilizer that contains helpful microorganisms. Select strains of beneficial soil microorganisms grown in the laboratory and packaged in appropriate carriers are often referred to as bio-fertilizer. In a broad sense, the word "bio-fertilizer" refers to any organic resources for plant development that are converted into a form that may be absorbed by plants through microbes, plant associations, or interactions [6], [7].

History of bio-fertilizer:

Rhizobium, Azotobacter, Azospirillum, and Blue green algae (BGA) have long been used as io-fertilizers. Applied microbial inoculum knowledge has a lengthy history that has been passed down from generation to generation of farmers. It all began with a culture of small-scale compost manufacturing, which has clearly shown the bio-capacity. Fertilizer’s when the culture accelerates the breakdown of organic wastes and agricultural by-products via different processes and provides a healthy crop yield, this is acknowledged. The commercial history of bio-fertilizer started in 1895, when Nobbe and Hilther introduced "Nitragin." The discovery of Azotobacter, then Blue-green algae, and a slew of other microbes followed, all of which are still utilized as bio-fertilizers today.

Industrial scale production of microbial inoculants began in Malaysia in the late 1940s and accelerated in the 1970s, guided by Bradyrhizobium inoculation on legumes. In the inter rows of

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young rubber trees in big plantations, the Malaysian Rubber Board (MRB), a government research institute, has been doing research on Rhizobium inoculums for leguminous crops. In addition, since the 1980s, University Putra Malaysia (UPM) has performed many studies on Mycorrhiza, including a study to determine the contribution of nitrogen from Azospirillum to oil palm seedlings. Bio-fertilizers are typically made up of carrier-based inoculants that contain beneficial microorganisms. Nitrogen fixers (N. fixers) such as Rhizobium Spp., Cyanobacteria, and Azotobacter chroococcum, potassium solubilizers (K – solubilizers) such as Bacillus mucilaginous, phosphorus solubilizers (P – solubilizers) such as Bacillus megaterium, Aspergillus fumigatus, Plant Growth Promoting Rhizobacteria [8], [9].

Carrier materials utilized in bio-fertilizer production:

Bio-fertilizers are often modified with carrier material to improve their efficacy. It also increases the amount of water that may be rationed. The following qualities must be present in a suitable carrier material. It must be inexpensive and easily accessible in sufficient quantities. It should be simple to sanitize through autoclave or gamma irradiation. It must be simple to work with and devoid of lump-forming elements. It must be harmless to both microbes and plants on which it is used. It must be able to absorb a lot of moisture. It must be capable of retaining more than 50% of its weight in water. It must have excellent seed adhesion. It must be capable of buffering pH. It must contain a high percentage of organic materials.

Microorganisms incorporated into carrier materials allow for simple handling, long-term storage, and bio-fertilizer efficacy. They also said that sanitation of carrier materials is required in order to retain large numbers of inoculants on them for extended periods of time. Saw dust, talcum dust, manure, and earthworm cast are examples of carrier materials. Because the sterilization procedure has no effect on the material's physical or chemical characteristics, gamma-irradiation is the best option for carrier sterilization. Autoclaving is another technique of carrier sterilization. Autoclaving, on the other hand, may alter the characteristics of certain carrier materials, resulting in the creation of poisonous chemicals that may kill some germs.

Biofertilizer production:

When creating bio-fertilizers, many factors must be addressed, including the microbe's development profile, the kinds and optimal circumstances of the organism, and the formulation of the inoculum. The inocula composition, application technique, and product storage are all essential to the biological product's success. In general, there are six stages involved in the production of biofertilizer. These include active microorganism selection, target microbe isolation and selection, propagation technique and carrier material selection, phenotypic testing, and large-scale tests.

First and foremost, the active microorganisms to be utilized must be decided. For example, whether to employ organic acid bacteria, nitrogen fixers, or a mix of species must be chosen before target microorganisms can be separated. Typically, organisms are separated from plant roots by enticing them in with a decoy, such as cold rice buried underneath bamboo plants. The isolated organism will next be cultivated on Petri plates before being mass-produced in flasks. It is also critical to choose the appropriate carrier material. Apioca flour or peat are the best carrier materials to utilize if you want to make bio-fertilizer in powder form. The purpose of choosing a propagation technique is to determine the organism's optimal growing conditions. This may be accomplished by calculating the growth profile under various parameters and circumstances, then testing and

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selecting the phenotype. Finally, the bio-fertilizer is put to the test on a wide scale in various environments to determine its efficacy and limits [10], [11].

2. DISCUSSION

Bio-fertilizers serve a critical role in increasing soil fertility. Furthermore, their application to soil enhances soil structure and reduces the need of chemical fertilizers. Under low-land circumstances, combining blue green algae (BGA) with Azospirillum resulted in a substantial increase in grain production. With rock phosphate as a phosphate fertilizer, bio-fertilizers inoculated with Azotobacter and Rhizobium and Vesicular Arbuscular Mycorrhiza provided the greatest increase in straw and grain production of wheat plants. Azolla is a low-cost, low-cost, low-cost, low-cost, low-cost, low-cost, low-cost, low-cost, low-cost, low-cost, low-cost, low-cost, low-cost, low Microorganisms such as Bacillus subtilis, Thiobacillus thioxidans, and Saccharomyces species have been found to fix atmospheric nitrogen symbiotically, with soya bean symbiosis supplying 80–90% of nitrogen requirement.

A major function of bio-fertilizer in agriculture may be bio-control, a contemporary method to disease management. Mung bean root rot has been discovered to be controlled by bio-fungicides based on Trichoderma. Bio-fertilizers including bacterial nitrogen fixers, phosphate and potassium solubilizing bacteria, and microbial strains of certain bacteria substantially improved the growth, yield, and quality characteristics of some plants. The following are some of the benefits of biofertilizers: Plant growth hormones are secreted, which aid in plant development. The protection of the plant against diseases, Soil fertility improvement, when utilizing bio-fertilizer, no additional precautions are required. Bio-fertilizers are less expensive than synthetic fertilizers, resulting in a reduction in the usage of chemical fertilizers. Bio-fertilizers promote plant development, restore the soil's natural nutrient cycle, and increase soil organic matter, as well as providing drought resistance.

3. CONCLUSION

Our reliance on chemical fertilizers and pesticides has fueled the growth of businesses that produce life-threatening substances that are not only harmful to humans but also disrupt the natural balance of the environment. In fact, due of the negative consequences that these foods have on the body when eaten, the focus is now moving from eating food produced with chemical fertilizers to consuming food grown with organic fertilizers. Bio-fertilizers may assist in addressing the issue of the world's ever-increasing food need. It is essential to recognize the benefits of bio-fertilizers in order to incorporate them into contemporary agricultural practice. Crop production is boosted to a great degree by the use of bio-fertilizers containing beneficial microorganisms. As eco-friendly and cost-effective inputs for farmers, these prospective biological fertilizers would play a significant role in soil production and sustainability, as well as protecting the environment. A low input system may assist to achieve agricultural sustainability by using biological and organic fertilizers. If discovered and transmitted to beneficial plant growth boosting rhizobacteria, the new technology created utilizing molecular biotechnology may improve the biological pathways of phytohormone synthesis. This technology will aid in the alleviation of environmental stressors. However, one of the few limiting aspects to bio-fertilizer use is a lack of knowledge on better bio-fertilizer application methods in the field.

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