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Review On Bio-Fertilizers, Substitution of Synthetic Fertilizers in Cereals for Leveraging Agriculture

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ABSTRACT: Crop plants need essential nutrients such as nitrogen and phosphorus to grow and develop. Extreme environmental risks have been reported as a result of the overuse of synthetic fertilizers. As a result, bio-fertilizers have a huge potential to enhance plant nutrition while also being environmentally benign by replacing synthetic fertilizers. Bio-fertilizers have a fantastic propensity to reduce the need for synthetic fertilizers while maintaining crop production. Plant growth promoting rhizobacteria (PGPR) such as Azotobacter and Azospirillum, as well as phosphorus solubilizing bacteria (PSB) such as Pseudomonas sp. and Bacillus sp., are found in bio-fertilizers and are capable of fixing atmospheric nitrogen and solubilizing soil phosphorus, respectively. As a result, they meet cereals' nitrogen and phosphorus requirements while simultaneously improving soil fertility. As a result, employing nitrogen-fixing and phosphorus-solubilizing bacteria as bio-fertilizers offers enormous potential for utilising atmospheric nitrogen and fixed phosphorus in the soil in crop production while causing no damage to the aerial and soil environment. Bio-fertilizers are more cost-effective than synthetic fertilizers owing to lower market costs, and they aid in strengthening soil structure and environmental restoration for agricultural leverage.

KEYWORDS: Azotobacter Bacillus, Bio- Fertilizers, Plant growth promoting rhizobacteria (PGPR), Pseudomonas, Synthetic.

1. INTRODUCTION

Crop plants need certain mineral components in order to get the nutrients they need to grow and develop. The nutrients nitrogen and phosphorus are yield limiting. To have the best crop production, essential nutrients must be available in the right amounts. Due to the increasing use of synthetic fertilizers in order to enhance output per unit area, modern agriculture is experiencing serious environmental contamination and degradation of land resources. To replenish soil nitrogen and phosphorus, massive amounts of synthetic fertilizers are used, which has negative environmental consequences. As a result, ecofriendly agriculture is becoming a new area of study as a means of reducing the negative consequences of commercialized farming. The increasing significance of bio-fertilizers will reduce the need for synthetic fertilizers, which will aid in environmental restoration. A biofertilizer is an organic substance made up of live microorganisms that are extracted from plant roots or soil. Bio-fertilizer is becoming increasingly popular as a substitute for synthetic fertilizer, lowering crop production costs and improving growth, development, and crop yield by supplying and increasing nitrogen availability and producing certain substances that aid plant growth, such as auxin, cytokinin, and gibberellins. Microbial activity is crucial in agriculture because it facilitates the transport and availability of minerals required for plant development, reducing the need for synthetic fertilizers [1]–[3].

1.1. Plant Growth Promoting Rhizobacteria (PGPR):

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Plant growth promoting rhizobacteria (PGPR) are a diverse group of bacteria that affect plant development and are classified as neutral, harmful, or beneficial. However, plant growth-promoting rhizobacteria are beneficial, and their favorable effects have been put to practical use in a variety of ways, including as bio-fertilizers, disease checkers, and probiotic qualities. Bacillus, Azotobacter, Pseudomonas, Azosprillum, and Enterobactor are some of the genera that promote plant development. However, Pseudomonas and Bacillus are the most common rhizobacteria that promote plant development [4], [5].

1.2. PGPR's Impact on Soil and Cereals Yield, Growth, and Development:

PGPR increases the availability of scarce nutrients while also increasing crop plant nutrient absorption capability. The growth and development of crops are aided by the synergistic actions of nitrogen-fixing and phosphorus-solubilizing bacteria. Rhizobacteria that regulate plant development have traditionally been employed in nonleguminous crops including rice, maize, and wheat. In rice, sorghum, barely, and maize, Bacillus species inoculation has resulted in a favorable yield response. Due to the high nutrient absorption capability of roots, wheat (Triticum aestivum L.) seed treatment with plant growth boosting rhizobacteria has demonstrated a hopeful rise in wheat production. Azotobacter, Bacillus, and Azospirillum are the bacterial genera implicated in PGPR. The use of Bacillus species in the seed treatment of wheat and barley has resulted in an improvement in crop production. Similarly, wheat seed treatment with Bacillus sp. increased root growth, soil structure, and plant development. Instead of a single application, a collective seed treatment with nitrogen-fixing and phosphorus-dissolving bacteria is more successful [6], [7].

Bio-fertilizers protect agricultural plants from dangerous soil diseases while also increasing the availability of vital nutrients. Using both nitrogen fixing and phosphorus solubilizing bacteria together increases yield in sorghum and barley, compared to using either nitrogen fixing or phosphorus solubilizing bacteria alone. Wheat seed treated with Pseudomonas putida and Baccilus lentus resulted in improved seed germination, seedling growth, and wheat production. Wheat seed inoculation with Azotobacter increases all yield metrics as well as the crop's ultimate yield, both alone and in combination with phosphorus-solubilizing bacteria. The use of nitrogen-fixing bacteria (Azotobacter chroococcum) as a bio-fertilizer boosts wheat biological output. When used as a source of bio-fertilizer in wheat, a combination of Azotobacter chroococcum and Bacillus magatherium produced better results in plant development than a single application of Bacillus magatherium.

Wheat cultivars were inoculated with PSB and nitrogen-fixing bacteria, and the results were superior than the control treatment. The inoculation of Azotobacter chroococcum resulted in a ten percent rise in non-leguminous crop yields and a 15 to 20 percent increase in cereal crop yields. Because of its unique capacity to fix atmospheric nitrogen and make it accessible to crop plants, Azotobacter is extensively employed as an inoculant in agricultural crops. Combining flax seed treatment with nitrogen-fixing bacteria (Azotobacter sp. and Azospirillum sp.) and phosphorus-solubilizing bacteria (Bacillus sp.) increases the production of growth-promoting substances, which aid in plant cell multiplication and cell enlargement, and ultimately increases all growth parameters.

1.3. Plant Growth Promoting Rhizobacteria (PGPR) Mechanism:

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Rhizobacteria that promote plant development have a propensity to fix atmospheric nitrogen and produce specific metabolites such as auxin, cytokinin, gibberellins, hydrogen cyanide (HCN), phytohormones, and unstable compounds. Also generate mineral dissolving chemicals (phosphorus solubilization), rivalry, and internal resistance. Azotobacter has a high proclivity for producing chemicals such as Indole acetic acid (IAA), Gibberellins, vitamin B complex, and growth hormones, all of which have the potential to boost crop growth and production. The use of biological fertilization (Nitrogen fixing bacteria) in non-legume crops has resulted in significant growth gains. This rise may be attributed to biological nitrogen fixation as well as the synthesis of growth-promoting compounds such as IAA and Gibberellic acid. Plant growth boosting rhizobacteria are bacteria that aid in the development of plants [8], [9].

1.4. Microorganisms that Dissolve Phosphorus:

Bacteria are more capable of phosphorus solubilization than fungi. Bacillus, Pseudomonas, Rhizobium, and Enterobacter bacteria, in combination with Penicillium and Aspergillus fungus, are beneficial in the phosphorus solubilization process.

1.5. Phosphorus Solubilization Mechanism:

Some organic acids are generated during phosphorus solubilization, which lowers the pH, and acid phosphatases convert the organic phosphorus to inorganic form. This is the exact process by which phosphorus solubilizing bacteria make phosphorus available in the soil. Many microbial activities, including organic acid generation and proton extrusion, aid in increasing phosphorus solubilization in soil. Bacteria and fungi that aid in the conversion of insoluble organic and inorganic soil phosphorus have been discovered.

The soil phosphorus solubilizing bacteria produce organic acids (gluconic and ketogluconic acids) that dissolve the soil phosphorus while also lowering the pH of the soil. The solubilization of phospate is influenced by both a decrease in pH and the formation of organic acid. Phosphorus bio-fertilizers create plant growth-promoting chemicals by increasing the mobility of fix phosphorus via a solublization process, as well as the availability of iron and zinc. The combination of phosphorus-solubilizing bacteria with nitrogen-fixing bacteria, such as Azospirillum and Azotobacter, has been shown to have a synergistic impact. PSB has been shown to increase phosphorus fertilizer efficiency by 10% to 25% throughout the globe [10].

1.6. Crop Production and Phosphorus-Solubilizing Bacteria:

Plants are unable to absorb enough phosphorus for growth and development because mineral phosphorus is extremely insoluble. The phosphorus dissolved by microorganisms may boost agricultural plant yields by up to 70%. Because phosphorus solubilizing microorganisms have a high tendency to increase the provision of soluble phosphate and increase the growth and development of crop plants by enhancing biological nitrogen fixation, the application of PSB has resulted in higher crop yields due to efficient dissolving of unavailable phosphorus present in the soil and artificially applied phosphorus. The combination use of phosphorus solubilizing microorganisms and plant growth boosting rhizobacteria resulted in a 50% decrease in phosphate application without lowering maize output. PSB inoculation has been shown to increase sugarcane production by up to 12.6 percent.

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PSB activity causes phosphorus to be mobilized, and as a consequence, phosphorus absorption within the plant body rises, resulting in improved plant growth and development. The use of PSB as a bio-fertilizer lowers the pH of the soil, which increases the solubility of certain minerals including phosphorus, iron, zinc, manganese, and copper. As a result, plant nutrient absorption improves.

2. Types of plant growth-promoting rhizobacterial biofertilizers

2.1. Nitrogen-fixing organisms:

Plants absorb nitrogen from the soil as nitrates (NO3) and ammonium ions (NH4+), which are frequently scarce in soil. As a result, artificial N fertilizers are often used to boost plant N nutrition. Alarmingly, the worldwide demand for synthetic nitrogen is quickly increasing, with the Food and Agriculture Organization (FAO) estimating that it already surpasses 130 million tons per year, which is inappropriate for the environment, particularly because its production is heavily reliant on fossil fuels. Biological nitrogen fixation (BNF) is a well-studied process in which some microorganisms utilize the nitrogenase enzyme complex to fix nitrogen for plant usage. The N2-fixing rhizobia of leguminous plants, for example, have been studied for decades. Several controlled experiments involving the inoculation of various crop plants with N-fixers have demonstrated that plants infected with N-fixers had higher N fixation and biomass production than non-inoculated controls. Several examples of rhizobacteria producing BNF with the potential to be utilized as biofertilizers for various crops. Some of these bacteria have been successfully formed into commercial biofertilizers, however most commercially available N biofertilizers are made up of Rhizobium and a few other bacteria such as Azotobacter and Azospirillum species, and are extensively used in legume crops.

Inoculating crops and agricultural areas with BNF-capable PGPR may assist in supplying the necessary N levels. In legume fields, evidence suggests that rhizobial N2 fixation rates of 1–2 kg N ha-1 day-1 may be achieved. Herridge suggested that replacing chemical fertilizers with rhizobial inoculants will lower yearly N fertilization costs from $30 million to about $1 million. The examples given highlight the significance of symbiotic and associative N2-fixing rhizobacteria. Nonetheless, new strains must be tested in the field for compatibility and adaptability before being used as inoculants.

Free-living diazotrophs including Azotobacter, Azospirillum, Gluconaceobacter, and Burkholderia have been used to show endophytic and associative N2 fixation in non-leguminous crops for decades. For example, studies have shown that with BNF and rhizobial inoculants, grain yields in Brazil, Argentina, and the United States of America (USA) may reach up to 4 t ha-1 each growing season. Similarly, N2 fixation rates of up to 40 kg N ha-1 year-1 have been recorded in Australian soils. The contribution of symbiotically-fixed N to plants, on the other hand, is mainly unknown and unproven. More study is certainly needed in this field, particularly for crops like grains, vegetables, and tubers, which account for the majority of human sustenance.

2.2. Nutrient solubilizers:

2.2.1. Phosphate solubilizers:

Phosphorus is the second most important macronutrient for plants. Plants can only take up monobasic (H_2PO_4) or dibasic (HPO_42) ions, but 95 to 99 percent of soil P is in insoluble, immobilized, or precipitated forms that are unavailable to plants. As a result, crops may only use a tiny proportion of total soil P, which is seldom enough. Because of its ability to solubilize P, several PGPR have piqued researchers' interest as plant inoculants. Because many agricultural soils have a P deficit, such species have been suggested as potential P biofertilizers. P-solubilizing bacteria (PSB) produce different enzymes and metabolites that solubilize P, according to the literature, although P solubilization is mainly promoted to occur by acidification. Recent research has effectively shown that Pseudomonas frederiksbergensis' P solubilizing capabilities are favorably linked with the formation of organic acids.

2.2.2. Solubilizers for potassium:

Although potassium is the third most important plant macronutrient, more than 90% of soil K is insoluble complexes, and accessible amounts are typically inadequate for plant development. According to reports, K shortage is a significant problem in agricultural productivity throughout the globe. Artificial K fertilizers are often used to replenish K in agricultural soils, although they are expensive and have a negative impact on farmers' profit margins. It is thus critical to discover new methods to increase K availability in order to keep agricultural production going. The capacity of PGPR to solubilize K from K-bearing rocks by secreting organic acids has been extensively studied, and K solubilizing bacteria (KSB) have been shown to play important roles in crop development and yield. According to studies, these bacteria may substantially enhance crop germination, nitrogen absorption, growth, and yield in both controlled and field environments.

Despite the fact that the solubilization of K-bearing rocks may not completely meet total plant K needs like commercial fertilizers, studies indicate that this innovative method may substantially increase K availability in agricultural soils. Furthermore, research shows that using KSB to agricultural soils as biofertilizers may significantly reduce the usage of chemical fertilizers while also being environmentally beneficial crop production methods. Indigenous KSB are gaining traction as one of the most promising solutions for addressing K shortage in agricultural soils.

2.2.3. Solubilizers for zinc:

Zinc is an important plant micronutrient that is involved in a variety of primary and secondary metabolic activities. Zn insufficiency is a widespread issue in most agricultural soils, according to existing studies, owing to nutrient mining during crop harvesting and increasing usage of NPK fertilizers with lower levels of these elements. Synthetic Zn fertilizers, at suggested rates of about 25 kg ha-1 ZnSO4 heptahydrate, are often used to supplement these deficits (equivalent to 5 kg ha-1 Zn). Nonetheless, these synthetic fertilizers are ineffective and quickly degrade into insoluble and inaccessible forms for plants.

3. DISCUSSION

Biofertilizers are rapidly gaining traction as an important part of agriculture operations throughout the globe. These microbial products are already in use in certain countries with great success, and their usage is anticipated to grow. A growing number of research are being conducted to isolate, identify, and assess the ability of PGPR to be converted into inoculants for a range of crops. As a result, it is fair to anticipate that the widespread use of biofertilizers will soon provide a variety of methods for the overall development of sustainable crop production systems. However, greater widespread use of biofertilizers would need appropriate regulatory and legal frameworks, which are presently restrictive and a barrier to their effective use. Fortunately, regulatory authorities have recently been more supportive of the use of alternate crop fertilization methods in order to encourage the development of sustainable agricultural technology. For example, the European Commission published a proposal to modify current rules after recognizing the need for a special legal framework for biofertilizers/biostimulants in Europe. Such efforts will ultimately loosen regulatory restrictions, allowing for broad use of microbial resources.

While many current biofertilizers are likely to be made up of non-transformed rhizobacterial strains chosen for their beneficial characteristics, the development of genetically engineered rhizobacterial inoculants that are more effective at promoting plant growth is needed. The greatest challenge for scientists will be demonstrating to the general public and regulatory agencies across the globe that genetically modified organisms do not pose any new dangers or concerns.

Our capacity to utilize the plant microbiome in agriculture and alter plant microbiomes in situ is currently restricted, and additional experiments are required to improve our knowledge and allow large-scale application and commercialization. The inoculant business has a number of difficulties when it comes to creating formulations with extended shelf life. The development of formulations with longer shelf life, broader action spectrum, and consistent field performance may speed up the commercialization of this technique. New biotechnological methods should be explored in this respect in order to create formulations with extended shelf life. Microencapsulation is one feasible option, however much of the research has been limited to labs, and the technique needs be standardized for industrial and field use.

4. CONCLUSION

The development and implementation of sustainable agriculture techniques is the biggest worldwide problem of the twenty-first century. Only by incorporating evolving and sophisticated technology, such as the utilization of effective rhizobacterial biofertilizers, will we be able to accomplish this. This research shows that bio-inoculants generate growth-promoting chemicals in plants, which boost nitrogen and phosphorus availability and, as a result, improve crop production. Bio-fertilizers may reduce or eliminate the usage of synthetic fertilizers, reducing environmental risks while also improving soil structure and promoting sustainable agriculture. Biofertilizers are less expensive and have a substantial impact on cereal crop production. Bio-fertilizers in cereals, orchards, flowers, and vegetables need further research to discover new and improved agronomic efficiency.

REFERENCES:

[1] R. Dineshkumar, R. Kumaravel, J. Gopalsamy, M. N. A. Sikder, and P. Sampathkumar, “Microalgae as Bio-fertilizers for Rice Growth and Seed Yield Productivity,” *Waste and Biomass Valorization*, 2018, doi: 10.1007/s12649-017-9873-5.

[2] D. Mishra, S. Rajvir, U. Mishra, and S. Kumar, “Role of Bio-Fertilizer in Organic Agriculture: A Review,” *Res. J. Recent …*, 2013.

[3] K. S. Saeed, S. A. Ahmed, I. A. Hassan, and P. H. Ahmed, “Effect of bio-fertilizer and chemical fertilizer on growth and yield in cucumber (cucumis sativus) in green house condition,” *Pakistan J. Biol. Sci.*, 2015, doi: 10.3923/pjbs.2015.129.134.

[4] M. Ahemad and M. Kibret, “Mechanisms and applications of plant growth promoting rhizobacteria: Current perspective,” *Journal of King Saud University - Science*. 2014, doi: 10.1016/j.jksus.2013.05.001.

[5] P. Vejan, R. Abdullah, T. Khadiran, S. Ismail, and A. Nasrulhaq Boyce, “Role of plant growth promoting rhizobacteria in agricultural sustainability-A review,” *Molecules*, 2016, doi: 10.3390/molecules21050573.

[6] F. Pérez-Montaño *et al.*, "Plant growth promotion in cereal and leguminous agricultural important plants: From microorganism capacities to crop production," *Microbiological Research*. 2014, doi: 10.1016/j.micres.2013.09.011.

[7] F. Pérez-Montano *et al.*, "Plant Growth promotion in cereal and leguminous agricultural," *Microbiol. Res.*, 2014.

[8] V. Jeyanthi and S. Kanimozhi, "Plant growth promoting rhizobacteria (PGPR)-prospective and mechanisms: A review," *Journal of Pure and Applied Microbiology*. 2018, doi: 10.22207/JPAM.12.2.34.

[9] "Plant Growth Promoting Rhizobacteria (PGPR) and their various mechanisms for plant growth enhancement in stressful conditions: a review," *Eur. J. Biol. Res.*, 2018, doi: 10.5281/zenodo.1455995.

[10] Y. Wei *et al.*, "Effect of organic acids production and bacterial community on the possible mechanism of phosphorus solubilization during composting with enriched phosphate-solubilizing bacteria inoculation," *Bioresour. Technol., 2018,* doi: 10.1016/j.biortech.2017.09.092.