The Comparative Study of Biofertilizers on Growth and Yield of Wheat: A Review

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Abstract:- Biofertilizers are chemicals containing live microorganisms that colonize the rhizosphere and stimulate plant development by boosting the availability of primary nutrients. They are used for seedling root dip, seed, or soil treatments and can significantly improve plant growth, production, and quality. Improving yield quality is crucial in wheat production due to changing climatic circumstances, as a lack of it can harm both animal and human health. Effective micronutrient management improves Wheat productivity is enhanced by improving plant tolerance to environmental stresses and diseases. Azospirillum, a soil-based plant growth-promoting rhizobacteria (PGPR) commonly found in grasses, rice, wheat, and sugarcane crops, is a beneficial bacterium used as a biofertilizer for rice agriculture. Biofertilizers use live microorganisms in sterilized carrier materials to mobilize Plant nutrients used for crop development, such as biological nitrogen fixation, phosphorus solubilization, and other nutrient mobilization. Some biofertilizers are also effective biocontrol agents, controlling root-borne diseases and improving soil fertility. Nutritious diets are essential for the rising population and plant development and output. Inorganic chemical fertilizers are widely employed in soil management, but they pose significant health and environmental risks. Biofertilizers have been identified as a potential option for enhancing soil fertility and crop yields in sustainable agriculture. Beneficial microorganisms are becoming more popular as biofertilizers in agriculture due to their potential influence on food safety and sustainability.

Keywords:- *Biofertilizers, Phosphorus Solubilization, Sustainability, Wheat Productivity, Microorganisms*

I. INTRODUCTION

Wheat (*Triticum aestivum* L.) is a significant source of calories, protein, and fiber in the human diet. It is a staple food for over 35% of the world's population and the most significant cereal crop on the global scale. Semi-dwarf, high-yielding wheat cultivars were developed in the 1960s, resulting in large improvements in wheat yields across traditional wheat belts (Rajaram, 1999). Since the mid-1990s, breeding has not resulted in significant yield increases. According to Rosegrant *et al*. (1995), the global demand for wheat in 2020 is estimated to be between 840 and 1,050 million tons. To meet rising demand, the world average grain yield need increase from 2.5 to 3.8 t/ha. Micronutrient deficiency in soil is a major issue in modern agrochemistry, affecting crop yields for wheat and other cereal crops. While global wheat output has expanded, its quality has not improved, potentially harming both animal and human health. Wheat is the world's most frequently farmed crop, covering 217 million hectares annually and producing over 700 million tons due to its numerous nutritional benefits (Erenstein, *et al.*,2022) . Wheat is evaluated mostly based on its grain quality in the global market. Plant products offer significant nutritional value and quantity. The nutritional value of plant products impacts both human and animal health. Micronutrient deficiencies affect more than 2 billion people, or 25% of the world's population, and are a leading cause of mortality and illness (Miner *et al*., 2022; Tulchinsky *et al*., 2010). This phenomena also occurs in plants. Wheat lacks important micronutrients, but can be supplemented using micronutrient fertilizers (MNF) (Cakmak, *et al*., 2018).

A biofertilizer is an organic fertilizer fortified with beneficial microorganisms. Microbes, plant associations, or interactions transform organic resources for plant development into useable form, resulting in biofertilizers. Biofertilizers employ live or dormant microorganisms (bacteria, fungus, algae, and actinomycetes) to fix atmospheric nitrogen, solubilize soil nutrients, and create growth-promoting chemicals to increase crop growth and production (Dineshkumar *et al*., 2018).

II. TYPES OF BIOFERTILIZER

A. Nitrogen Fixing Biofertilizers

Gupta *et al.* (2012) found that nitrogen is the limiting nutrient for plant development. Although the atmosphere contains around 80% free nitrogen, most plants are unable to utilize it. Nitrogen must be fixed by a certain type of bacteria before it can be used by plants. Biological nitrogen fixers (BNFs) are microorganisms that fix nitrogen in the environment. According to Reed *et al*. (2011), they transform inert N2 into an organic form for plant use. Nitrogen-fixing bacteria are categorized into three types: free-living bacteria (Azotobacter and Azospirillium), blue-green algae, and symbionts. Rhizobium, Frankia, and Azolla are among examples. Rhizobium, Azorhizobium, Mesorhizobium, Sinorhizobium, Allorhizobium, and Bradyrhizobium are N2-

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fixing bacteria associated with legumes, whereas Achromobacter, Alcaligenes, Arthrobacter, Acetobacter, Azomonas, Beijerinckia, Clostridium, Bacillus, Enterobacter, Erwinia, Desulfovibrio, Derxia, Corynebacterium, and Campy are associated with nonlegumes. Plant roots in the rhizosphere produce chemicals that promote bacterial colonization and nitrogen fixation. Although Numerous rhizosphere species, including Azotobacter and Azospirillum have been widely tested in the field to increase legume and grain yields (Bhat *et al*.,2015).

Table1: Types of Biofertilizer

Biofertilizer	Microorganisms associated
Nitrogen fixing	**Rhizobium, Azotobacter, Azospirillum,Radyrhizobium**
Phosphorus Solubilizing (PSB)	**Bacillus, Pseudomonas, Aspergillus.**
Plant Growth Promoting	**Pseudomonas**
Phosphorus solubilizing (Fungi)	**Mycorrhiza**
Algae	**Cyanobacteria and Azolla sp**

B. Biofertilizer for phosphorus solubilization and mobilization.

Phosphorus, which accounts for 0.2% of a plant's dry weight, is necessary for its growth and development. Phosphorus is the least transportable macronutrient accessible to plants in a variety of soil types. Microorganisms can transform insoluble phosphate into soluble forms (Kalayu, 2019;Prabhu *et al.*, 2019). Several bacterial and fungal species help with phosphate solubilization (Antoun, 2012). Phosphate-solubilizing bacteria (PSB) convert insoluble phosphates, such as HPO4 and H2PO4, into soluble forms by producing organic acids, chelating, and exchanging ions.

C. Sulfur Oxidizing Biofertilizers

Sulfur is an essential element for plants. Sulfur has been demonstrated to enhance soil's biological and physical qualities. Sulfur has been demonstrated to enhance soil's biological and physical qualities. Sulfur's ability to buffer soil pH is well-known. Previous research (El-Halfawi *et al*., 2010) suggests that sulfur enhances the effectiveness of nitrogen and phosphate fertilizers, as well as plant micronutrient absorption. Most agricultural soils have bacteria that can oxidize sulfur.

Sulfur oxidizing bacteria (SoxB) are the most important microorganisms from the Thiobacillus genus. hiobacillus sp., including thiobacillus thioparous, can oxidize sulfur into plant-usable sulfates that improve plant nutrition (Riaz *et al.*, 2020; Vidyalakshmi *et al.*, 2009).

D. Biofertilizers that solubilize and mobilize potassium

Potassium is the second most essential nutrient for plants, following nitrogen and phosphorus. Plants can only absorb 1% - 2% of available phosphorous in soil, while the rest is in the form of mineral K that plants cannot absorb. soil solution K requires regular replenishment (Park *et al.*, 2009; Meena *et al.*, 2014).

E. Plant roots and soil microorganisms interaction

Plant-associated microorganisms convert carbon from plants into minerals present in soil. Mycorrhiza-assisted plant uptake is characterized by the availability of low diffusion rate nutrients such as phosphorus (P), zinc (Zn), and sulfur (S) to plants via bacteria and mycorrhizal fungus, as well as the transfer of atmospheric nitrogen (N2) to soil and plant (Smith & Smith, 2012; Gahan & Schmalenberger, 2014). In addition to boosting limiting elements like as nitrogen and phosphorus, enzymes and hormones encourage root growth and increase nutrient use. Halpern *et al*. (2015) explored how biostimulants promote plant nutrient uptake through several ways. Biostimulants are substances or materials that can improve plant growth, development, or stress response. They exclude nutrients and herbicides. Plant growth promoting rhizobacteria (PGPR) help fix atmospheric N2, solubilize P and iron, and alter root morphology. Microbes can lower plant disease incidence by acting as root pathogen antagonists and establishing systemic resistance(Choudhary *et al*., 2011).

F. Enhancement on soil fertility

Research shows that mixing rhizobia secondary metabolites with biofertilizers can boost grain cropdevelopment and production. Krey *et al.* (2013) discovered that inoculating maize plants with a P- solubilizing Pseudomonas fluorescens strain resulted in faster growth and greater AMF infection rates than non-inoculated control plants. Kaur and Reddy (2014) developed two P-solubilizing bacterial strains that boost plant growth and soil fertility under a variety of agroclimatic situations.

Owen et al. (2015) investigated the nomenclature, composition, and functions of P solubilizers, as well as the variables that influence their efficacy in increasing P availability in various soil and plant settings. Research indicates that inoculating woody legumes with both AMF and rhizobia may promote growth (Lesueur *et al*., 2001; Lesueur & Duponnois, 2005).

G. The role of biofertilizers in crop production

Biofertilizers maintain soil nutrient levels by fixing nitrogen, solubilizing phosphate and potassium, releasing plant grpwth regulators, producing antibiotics, and degrading organic matter (Bhardwaj *et al*., 2014). Biofertilizers are gaining popularity as a safer substitute for chemical fertilizers in sustainable agriculture (Nosheen *et al*., 2021). Biofertilizers use microbes to transfernitrogen from the atmosphere directly to plants. Nitrogen-fixing bacteria play a significant role insoil Nitrogen fixation, contributing to the nitrogen cycle. Nitrogen fertilizer application leads to increased NO2 emissions. Naher *et al*. (2015) argue that biofertilizers have the ability to prevent global warming.

➢ *Role of PSB*

Using PSB in agriculture can reduce the high cost of phosphate fertilizers while also mobilizing insoluble nutrients in the soil. In soil, phosphate solubilizing bacteria (PSB) account for 1-50% of the microbial population, while phosphorus-solubilizing fungi (PSF) account for just0.1-0.5%. Beneficial effects of phosphore in (PSB) and artificial phosphorus fertilizer on Fiber beans demonstrated growth, yield, seed production, and quality. Improving P supply for crops through Phosphate solubilizing bacteria (PSB) can help address rising fertilizer prices and a lack of phosphorus in Indian soils. Sundara et al. (2002) found that using PSB in combination with P fertilizers decreased the need for P chemical fertilizers by 25%, while also improving sugarcane juice quality and productivity.

➢ *Role of VAM*

VAM fungi are important components of the soil microbiota and interact with other microorganisms in the rhizosphere. The study demonstrated that mycorrhizal inoculation significantly increased the development of transplanted chiles under field circumstances. The expanded hyphae network in VAM improves P absorption as well as the intake of Zn, Cu, Fe, Mn, and other nutrients. VAM fungal hyphae form macroaggregates by physically entangling soil particles and organic components. Aggregates improve carbon and nutrient storage, while also providing a favorable habitat for soil microbes to thrive. VAM fungi play a crucial role in organic and sustainable agricultural systems that prioritize biological disease management over agrochemicals. Aphanomyces, Cylindrocladium, Fusarium, Macrophomina, Phytophthora, Pythium, Rhizoctonia, Sclerotinium, Verticillium, Thielaviopsis, and nematodes are some of the soil-borne diseases that VAM fungus protect plants against.

➢ *Role of Azotobacter*

In a 2022 study, Kader *et al.* examined how Azotobacter inoculants affected wheat production and nitrogen absorption. Azotobacter, a free-living nitrogen fixer in the rhizosphere zone, has the potential to synthesize and release physiologically active chemicals suchas B vitamins, nicotinic acid, pantothenic acid, biotin, auxins, and gibberellins, all of which stimulate root growth. Kramany *et al.* (2007) discovered that using 25% NPK + 75% FYM + microbien led in the maximum groundnut production, yield components, oil yield (kg ha^{-1}), P (%),Fe and Zn (ppm), number of seeds/pod, and straw weight (g $plant^{-1}$).

III. IMPACT OF BIOFERTILIZERS ON SEED TREATMENT

A. Seed treatment and planting for Rhizobium culture

Dissolve 200g of jaggery in 200ml of water. a jaggery solution proportional to the seed volume was produced. To prepare theslurry, the Rhizobium culture was completely mixed with the aforementioned solution. The mixture was carefully applied on the seeds to avoid damaging the coat and provide a homogeneous covering. Treated seeds were shade-dried in gunny bags before planting.

B. To create an Azotobactor culture

Mix 200g of jiggery with 200ml of water. Jiggery solution was created in proportion to seed volume. To prepare the slurry, properly mix the Azotobactor culture with the solution mentioned above. Seeds were carefully treated with this mixture to avoid damaging the seed coat and provide a homogeneous covering. Treated seeds were dried in shade in gunny bags before sowing.

C. PSB cultivation:

PSB cultivation required dissolving 200g of jaggery in 200ml of water. A jaggery solution proportionate to the seed volume was prepared. PSB culture was fully mixed with the supplied solution to produce slurry. The mixture was carefully applied on the seeds to avoid damaging the coat and provide a homogeneous covering. Treated seeds were dried in shade in gunny bags before sowing.

➢ *Root and plant characteristics*

Inoculation with AMF or AMF + Azc enhanced peduncle length, flag leaf area, number of grains spike-1, grain weight, biological yield, and grain yield per plant (Fig. 1). Wheat varieties and crosses behaved differentially to AMF and AMF + Azotobacter inoculationsWH147 responded the most to AMF + Azotobacter inoculation, exhibiting increased flag leaf area, spike-1 number, grain production, and biological yield. In crosses, this parent resulted in greater magnitudes for these characteristics. The response was shown to be heritable on a variable level. Inoculating AMF with Azotobacter improved Azotobacter viability in wheat rhizospheres. AMF and Azotobacter complement one another, which promotes plant development. In crossbreeding, PBW175 demonstrated overdominance for root characteristics.

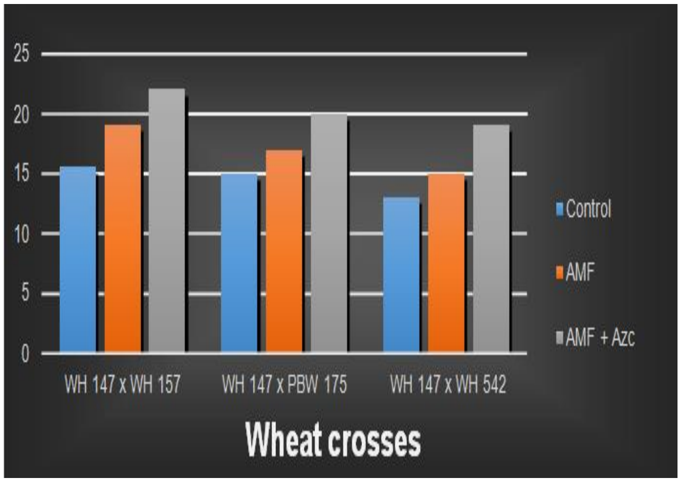

Fig 1 demonstrates how bioinoculants affect grain yield (g) in wheat crosses.

As a result, the potential for increased root biomass, total root length, and AMF infection of roots in PBW 175 looked heritable. Although AMF infection of roots in AMF treatments

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was equivalent for all crosses, inoculation with AMF + Azotobacter showed a greater effect on AMF in WH147 x PBW175 and WH147 x WH157. Wheat crosses responded differentially toAMF treatment, with highest increases in root biomass in cross WH147 x WH157 and total root length in cross WH147 x PBW175, but F1 crosses were equivalent in terms of AMF infection of roots. Total root length increased in all three crosses after dual inoculation, with the highest value observed in WH147 x PBW175.

IV. MICRO AND MACRONUTRIENT UPTAKE

Singh *et al*. (2004) discovered that inoculating three spring wheat varieties and F1 hybrids with AMF (G. manihotis) and rhizobacteria (A. chroococcum) increased biomass, root VAM infection,and nutritional content in low pH soil (pH 3.8). The hybrid WH533 x Raj3077 had a higher VAM infection rate in the roots (35.14%) and P content. WH147 x R3077 produced more plant biomass(3.00 g plant-1) and had better N content and absorption, with Fe, Cu, Mn, and Zn levels of 670ppm. VAM and Azotobacter inoculation increased Cu and Zn levels in shoots, whereas VAM inoculation enhanced Fe and Mn levels (singh *et al.*, 2007a). VAM infection in roots associated favorably with nitrogen and Zn content during Azotobacter inoculation, but P, Fe, Cu, and Mn concentration were highest during VAM inoculation. Under simultaneous inoculation, VAM infection in roots was positively correlated with P content (r=0.65), P absorption (r=0.53), Fe (r=0.85), Cu (r=0.36), and Zn (r=0.64).

- *Azospirillum*

Azospirillum is a microorganism that acts as a natural biofertilizer. This procedure involves fixing atmospheric nitrogen into staple crops such as rice, maize, sorghum, wheat, and millets. Azospirillum, a rod-shaped, gram-negative bacterium that promotes plant development, thrives in nitrogen-free semi-solid malate media. Azospirillum can live in both anaerobic and oxygen-consuming habitats, however it prefers micro-aerophilic situations to flourish. Its principal job is to produce IAA, which promotes growth, as well as to withstand disease and drought. This survey focuses on biofertilizer arrangements including Azospirillum as an inoculant.

- *Role of Biofertilizer in Agriculture*

Biofertilizers improve soil fertility (Kachroo *et al.*, 2006, Son *et al*., 2007). Collection improves soil structure and reduces need on artificial fertilizers. The combination of BGA and Azospirillum was highly effective in advancing LAI, even in challenging conditions.Grain yield and collection are directly impacted by biofertilizer usage. Incorporating Azotobacter, Rhizobium, and VAM into paddy fields resulted in higher straw and grain yields when shake phosphate was used as a fertilizer. Azolla is a low-cpst, affordable, and neighborly crop that enhances soil carbon and nitrogen levels. Something else Some commercial biofertilizersare also utilized to increase crop output. Raj (2007) discovered that microorganisms can be used as biofertilizers to dissolve micronutrients like zinc. According to Bieranvand *et al*. (2003), soybean plants can meet 80-90% of nitrogen needs through positive interactions.

- *What's the difference between biofertilizer and organic fertilizer?*

Biofertilizers can be solid or liquid, with large quantities of microorganisms (e.g., 10-7 cells per gram). Microorganisms provide nutrients to plants, acting as biofertilizers. Biofertilizers are element-specifoic. Organic manure is made from thoroughly decomposed animal and plant waste. Anonymous (2012a) suggests that it might serve as a medium for bio-fertilizers due to its high nutritional content in little doses.

- *Cyanobacteria (BGA : Blue Green Algae)*

Prokaryotic species like Nostoc, Anabaena, Oscillatoria, Aulosira, and Lyngbya improve paddy field soil by fixing atmospheric nitrogen, providing vitamin B complex, and growth-promoting chemicals, resulting in strong plant development. Applying cyanobacteriaat a rate of 10 Kg/ha can boost crop output by 10-15% and fix 20-30 Kg/N, according to Youssef and Ali (1998). Meloidogyne incognita, a root knot nematode that infects cowpea, created fewer galls and egg masses, leading to enhanced plant development.

V. CONCLUSION

Biofertilizer is a product made of microorganisms that colonize the rhizosphere and promote growth by making nutrients more accessible to the host plant. As biofertilizers, blue green algae, fungi, and bacteria are frequently used. The rhizosphere of the plant has these organisms availableto boost their activity in the soil. By increasing soil nutrient availability and nitrogen fixation, theyhelp plants in an indirect way. New breakthroughs in crop production must be reached without depleting natural resources or deteriorating environmental quality. In summary, biofertilizers are contributing significantly to the improvement of agricultural productivity in an environmentally sustainable way by reducing the use of chemical fertilizers and increasing plant nutrient use efficiency.

The most cutting-edge biotechnology and most necessary goods for the advancement of organic, sustainable, green, and pollution-free agriculture are those derived from biological sources. Plant growth is stimulated by biofertilizers because they replenish the soil's natural fertility and shield it from illnesses and drought.

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