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Biofertilizers Used in Rice Cultivation

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Abstract

The application of biofertilizers in rice cultivation offers a sustainable alternative to chemical fertilizers, enhancing both crop yield and soil health. Biofertilizers, comprising beneficial microorganisms such as BGA, *Azolla,* and *Azospirillum*, facilitate essential processes like nitrogen fixation, supplying N, the major nutrient which is of utmost importance in rice. Moreover, integrating biofertilizers into rice farming practices can reduce environmental pollution associated with excessive chemical fertilizer use, promoting ecological balance. The adoption of biofertilizers not only supports sustainable agriculture but also contributes to long-term soil fertility and productivity. To fully harness the benefit of biofertilizers in rice the right type of biofertilizer should be used in an integrated manner with chemical fertilizers. This avoids yield penalty while addressing environmental concerns.

1. Introduction

Global agriculture is marching ahead towards sustainability with the support of new advanced technologies, ideologies and various methods of resource efficient management practices. Alongside sustainability goals there hovers the need to increase the demand of food supply mainly the staple crops like rice, wheat and maize to feed the increasing population. Injudicious used of agriculture chemicals in these crops has been a common practice in nook and corner of the world since the green revolution. Needless to say the effects of synthetic chemicals are well pronounced, affecting the activities of life forms starting from microbes in soil to the health of humans. It has jeopardized the whole world either directly or indirectly with agriculture being one of the major cause. The global demand for fertilizer was estimated to be 195 million metric tons (MMT) [Statista, 2024]. Rice, being a staple food for more than 50% of the world population and being a major consumer of fertilizer specially nitrogen (N) is a major cause of the chemical crisis. As frequent reports of chemical residue in the food system being made, people are on their toes to develop and adopt ideas that can be a solution to the problem. One such technology is the use of biofertilizers, which are eco-friendly in addition to enhancement of plant

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health and microbiomes (Seenivasagan and Babalola, 2021). Biofertilizers, being a part of integrated nutrient management (INM) approach can ensure that rice crop receives essential nutrients in the right proportions while minimizing the adverse effects of excessive chemical fertilizer use, such as soil acidification and environmental pollution. This integrated strategy is particularly important in intensive cropping systems where continuous cultivation can otherwise lead to nutrient depletion and resource degradation. In addition, biofertilizers represent a promising climate-resilient approach in sustainable agriculture by leveraging beneficial microorganisms which naturally convert unavailable forms of essential nutrients into forms that plants can readily absorb. Overall, integrating biofertilizers into rice cultivation practices supports a low-carbon, sustainable, and resilient farming system, contributing significantly to food security and environmental conservation in a changing climate scenario.

2. Biofertilizers and its Types

Biofertilisers are fertilizers containing microbial innoculants either in living or latent form which when added to soil or seeds supplies nutrients and improves plant and soil health. There are different types of biofertilizers depending on the association with plants and nutrients involved. Some microbes are capable of fixing atmospheric N, while some can increase the availability of N and phosphorus (P).

Figure 1: Types of biofertilizers

3. Biofertilizers for Rice Cultivation

Nitrogen biofertilizers are necessary because nitrogen is a crucial nutrient for plant development, but it is often scarce in the soil. Plants require nitrogen to synthesize proteins, chlorophyll, and other essential substances, yet the majority of nitrogen in the atmosphere is in a form that plants cannot utilize directly. Certain microorganisms, some of which can establish different relationships with plants, have the ability to fix significant amounts of nitrogen. Rice is usually cultivated in water-saturated, low-oxygen environments that promote the growth of specific beneficial microorganisms, including blue-green algae (cyanobacteria) and other nitrogen-fixing bacteria.

3.1. Blue-green algae

It is also known as Cyanobacteria, a type of photosynthetic microorganism, well-known for their essential role in natural N cycles. They are especially significant in agricultural environments like rice paddies, where they enhance soil fertility by fixing N. Species like *Anabaena, Nostoc*, and *Oscillatoria* are capable of converting atmospheric N into ammonia, a form of N that plants can readily absorb, thus acting as natural biofertilizers. This process not only reduces the need for synthetic fertilizers but also promotes sustainable and eco-friendly agriculture.

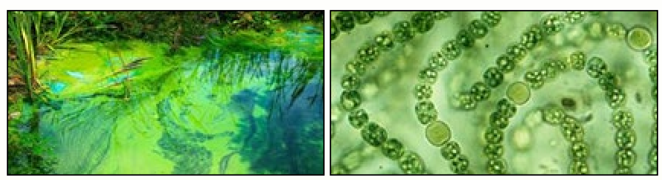

Figure 2: BGA growth on water surface; microscopic view of BGA

3.2. Azolla

It is a floating tiny water fern, which contains an endosymbiont, the N fixing cyanobacterium *Anabaena azollae,* within specialized cavities in its leaves. Inside these cavities, *Anabaena azollae* uses the enzyme nitrogenase to convert atmospheric nitrogen (N_2) into ammonia (NH_3). This conversion is energy-intensive and requires a low-oxygen environment, which is provided by the microhabitat within the *Azolla* leaves. The NH_3 produced is quickly incorporated into amino acids and other nitrogenous compounds. *Azolla* is either incorporated into the soil before rice transplanting or grown as a dual crop along with rice. *Azolla* leaves contain 4–5% nitrogen on dry weight basis, which after decomposition provides N to the plants. In addition to N it also provides K, P, Zn (Zinc) and Fe (Iron) to the crop. *Azolla* fixes 30-60 kg of N/ha/yr (Kollah et al., 2016) and increases rice yield up to 15-20% (Korsa et al., 2024).

Figure 3: *Azolla*; Paddy field with *Azolla*

3.3. Azospirillum

Azospirillum is a type of microaerophilic, non-fermentative bacteria that acts as a symbiotic diazotroph, commonly located in the roots and rhizosphere of rice plants. This bacterium colonizes both the surface and interior of the roots, where it fixes nitrogen. Additionally, it contributes to the production of phytohormones and the solubilization of nutrients, which helps plants cope with both biotic and abiotic stresses.

Figure 4: *Azospirillum* colonization on root surface

4. Production of Biofertilizers

4. 1. Blue Green Algae (BGA)

4.1.a. Trough method: First, shallow trays or troughs (2 meters long and 23 cm wide) are prepared and 8–10 kg of soil is thoroughly mixed with a small amount of superphosphate (about 200 g) and placed in the trough, then watered to a depth of around 5–15 cm. A starter culture is sprinkled on top, ensuring the pH remains between 7.0 and 7.5. The trough is then placed in sunlight to promote the growth of blue-green algae (BGA). After 7 to 10 days, a thick layer of algae develops on the water's surface, which is allowed to dry. The dried algal flakes are then collected and stored for use as inoculum.

4.1.b. Pit method: Farmers create shallow pits in the ground and cover them with a thick plastic sheet to hold water. After preparing the pit, they mix a specific amount of soil with a small quantity of superphosphate (SSP) and fill the pit with water to a depth of about 5–15 cm, then they introduce the inoculant. The subsequent steps are similar to those used in the trough method.

4.1.c. Field method: The process takes place in a well-kept open area of approximately 40m^2, where the field is irrigated to a height of 15cm and 20kg of SSP is applied. The pH level is kept around 7, after which 5kg of inoculum is introduced and the area is regularly watered. Within 3 to 4 weeks, BGA will grow, and the dry algal flakes can be harvested. A total of 30kg of BGA can be collected from the field.

4.1.d. Polythene lined method: A shallow pit, usually around 1 m^2 in size, is excavated in an open area and lined with a thick polythene sheet to prevent water from leaking out. Then, about 2–3 kg of soil is combined with roughly 100 g of SSP, and lime is added if necessary to achieve a pH of around 7. To reduce the risk of insect infestations, a small amount of insecticide (such as 2 ml of malathion) is mixed in. The pit is filled with water to a depth of about 10 cm and left to settle until the water is clear. Once the water is clear, a starter inoculum of blue-green algae (approximately 100 g per m^2) is evenly distributed over the surface of the water. In full sunlight and with temperatures between 35–40°C, the algae grow rapidly, forming a thick mat. This method allows for the harvesting of about 1 kg of pure dried algal flakes per m^2.

4.2. Azolla

It grows at a temperature of 20-30°C and soil PH of 5.5 – 7.0. It grows better during monsoon season with frequent rains and cloudiness. *Azolla* is applied to rice field as a green manure crop and as a dual crop. It is allowed to grow on flooded soils for 2-3 weeks before transplanting. Later, water is drained and *Azolla* is incorporated by ploughing in situ. As a dual crop, 1000-5000 kg/ha of *Azolla* is applied to the soil one week after transplanting. When a thick mat forms, it is incorporated by trampling. The left over *Azolla* develops again which is trampled in as a 2nd crop. For better growth of it, 25-50 kg of SSP/ha is applied and standing water of 5-10 cm is maintained continuously in the rice fields.

4.3. Azospirillum

Root samples are collected from target crops and *Azospirillum* strains are isolated using selective media, such as nitrogen-free bromothymol blue (NFB) semi-solid medium. A suitable growth medium, such as malic acid broth, tailored for *Azospirillum* cultivation is prepared. Then, inoculate the medium and incubate the culture under optimal conditions (30±2°C with agitation) until a high cell density (10^9 to 10^{10} CFU/ml) is achieved. Mix the *Azospirillum* broth culture with sterilized carrier material (peat, lignite, vermiculite, or charcoal) to achieve a moisture content of 40–50%, ensuring uniform distribution of the bacterial cells. After proper packaging cure them at room temperature for 2–3 days to stabilize the formulation.

5. Application of Biofertilizers in Rice

➢ Seed treatment- Seeds are mixed and uniformly coated in a slurry (inoculant is mixed with 1% jaggery) and then shade-dried, before being sown within 24 h. 200g of inoculant is sufficient for 10 kg of seed.

➢ Soil application- In this practice, dry flakes of BGA biofertilizer are applied directly to the soil either alone or in combination @ 10kg/ha over standing water, usually done in 2 days after transplanting in loamy soils and 6 days after planting in clay soils. Field is kept waterlogged for few days after application.

➢ For liquid biofertilizer application in rice, the required quantity of *Azospirillum* has to be mixed with 5–10 liters of water, the ratio of inoculant and water is 1:10. At one corner of the field and the roots of seedlings have to be dipped for a minimum of half-an-hour before transplantation.

6. Precautions before Application of Biofertilizers

➢ Biofertilizer packets need to be stored in a cool and dry place away from direct sunlight and heat.

➢ Right combinations of biofertilizers have to be used.

➢ Other chemicals should not be mixed with the biofertilizers.

➢ The packet has to be used before its expiry, only for the specified crop and by the recommended method of application.

➢ Biofertilizers are live products and require care in their storage.

➢ It is important to use biofertilizers along with chemical fertilizers and organic manures. Biofertilizers are not a replacement of fertilizers but can supplement plant nutrient requirements.

7. Conclusion

Biofertilizers represent a sustainable and eco-friendly alternative to synthetic fertilizers in rice cultivation. The integrated approach of biofertilizer as a supplement to chemical fertilizers not only boosts rice yields and overall crop quality but also contributes to the long-term health of the soil and ecosystem. As rice remains a staple food crop worldwide, adopting biofertilizer practices is essential for promoting agricultural sustainability, lowering production costs, and ensuring food security in the face of changing climatic conditions.

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