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Azolla Biofertilizer – The Nature's Miracle Gift for Sustainable Rice Production

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Abstract

Azolla is a fast growing free floating freshwater fern which fixes atmospheric nitrogen by forming a symbiotic association with a prokaryotic cyanobacterium -*Anabaena azollae*. It is a cost-effective, eco-friendly biofertilizer in lowland rice fields. As green manure in water logged soil, it enhances the rapid mineralization of nitrogen, improves the physical and chemical properties of the soil and increases soil microbial activities. It increases the rice yield equivalent to that produced by 30-60 kg N/ha. Azolla application is considered as a good practice for sustaining soil fertility and crop productivity.

Introduction

Azolla is a floating aquatic fern and belongs to Phylum-Pteridophyta; Class-Filicopsida; Order-Salviniales; Family-Azollaceae. It has branched, short, floating stem and bearing roots which float over water. Azolla has a characteristic bilobed leaf that consists of a dorsal and ventral lobe. The dorsal lobe is green or purple in colour and has a central cavity which houses the symbiotic blue-green alga *Anabaena azollae*. The ventral lobe is relatively thin and always remains partially submerged in water and provides buoyancy (Raja *et al.,* 2012). The worldwide distribution of Azolla is represented by following six recognizable species: *Azolla pinnata*, *A. filiculoides, A. rubra, A. microphylla, A. imbricate* and *A. caroliniana* and all these contain the *Anabaena azollae* association (Raja *et al*., 2012).

Azolla forms a symbiotic association with the prokaryotic blue-green alga *Anabaena azollae* (Figure 1). In this association, the eukaryotic partner Azolla provides shelterto the cyano-bacterium *Anabaena azollae* in its leaf cavities and also supplies carbon source. In return *Anabaena azollae* fixes atmospheric nitrogen and provides ammonia to the Azolla (Ana, 2018).

The *Anabaena azollae* is a prokaryotic cell containing three types of cells- vegetative cells, heterocysts and akinetes (Figure 1). The vegetative cells are highly pigmented whereas heterocysts are large, thick walled, lightly pigmented cells and the average heterocyst frequency is 7 to 20 %. The akinetes are not usually seen and these are the resting spores which are formed from the vegetative cells during unfavourable harsh climatic condition. Nitrogen fixation occurs inside the heterocyst which provides an anaerobic environment and in which the atmospheric nitrogen (N_2) is reduced to ammonia (NH_3) in the presence of the enzyme nitrogenase. The requirement of ATP and reductant ($NADPH^+$) for this reaction is obtained from the photosynthetic activity of the vegetative cells. An average of 35-50 % ammonia fixed by the cyanobacterium is released to the field and for this reason it is used as a biofertilizer in the rice fields (Ana, 2018).

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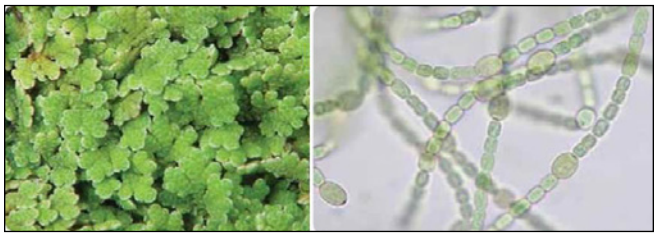

a) Azolla-a feee floating-aquatic fern b) Microscopic view of anabaena azollae

(Source- https://img.brainkart.com/extra3/7f3QMvI.jpg)

Figure 1: Azolla and its symbiotic Anabaena azollae

Azolla as Biofertilizer

Azolla biofertilizer is the most suitable for the lowland rice as both rice crop and fern require similar environmental conditions. Due to its rapid growth, high nitrogen fixing capacity, quick decomposition, Azolla is an eco-friendly and cost-effective biofertilizer. It is used as biofertilizer extensively in rice. It not only increases the fertility status of the soil but also improves soil health. It also suppresses weeds and reduces volatilization of ammonia in rice fields and substantially increases the amount of nitrogen fertilizer available to growing rice. It can able to reduce the cost of rice cultivation, improve soil health and boost yields sustainably (Muhammad *et al*., 2020). It has huge potential to increase global rice production and hence provides food security.

It can be utilized by rice in both wet and dry season. Azolla can be used in two ways: as green manure incorporated before transplanting, and as an intercrop incorporated after transplanting. In each case, about 500 kg (fresh weight) per ha is introduced into standing water in the rice field. About 5% of the nitrogen sequestered by Azolla is available immediately to the growing rice plants. The remaining 95% remains in the biomass of Azolla and as the Azolla decomposes, its organic nitrogen is rapidly mineralized and released as ammonia (30-60 kg N/ha), which then becomes available to the growing rice plants. The effectiveness of Azolla as a biofertilizer on rice depends upon various climatic conditions, methods of application and use of Azolla species etc. Azolla is used in rice cultivation in two ways: Pre-transplanting incorporation and Intercropped Azolla. Increase in grain yields of rice from 14% to 40% has been reported with Azolla being used as a dual crop. The use of Azolla as monocarp during the fallow season has shown to increase rice yield by 15-20 %.

Low Cost Technique of Azolla Multiplication in Nursery Bed

As Azolla multiplies vegetatively, so Azolla (inoculum) is maintained throughout the year by growing in small ponds or water filled open field. Azolla grows best at a 25 °C average daily temperature but dies at a higher temperature. For the production of the initial inoculum, a suitable semi-shade place is selected. Two feet depth pit is dug and a UV stabilized polythene sheet of 2 m × 2 m size is uniformly spread pit. About 10-15 kg of sieved soil is uniformly spread over the pit. Cow dung slurry is prepared by mixing 2 kg cow dung and 30 g of superphosphate mixed in 10 litres of water. The slurry is poured in the pit and then freshwater is added to raise the water level to about 10 cm. About 0.5-1 kg of pure mother Azolla culture seed material is spread uniformly over the water. The Azolla grows in the pit. After a week a mixture of 20 g of superphosphate and about 1 kg of cow dung should be added once in 5 days to maintain rapid multiplication of the Azolla. The Furadon granules (10 g) can also be added at fortnight intervals. Azolla will grow rapidly and fill the pit within 10-15 days. From then on, 500 - 600 g of Azolla can be harvested daily and used for further multiplication.

Azolla Biofertilizer Application

It can be utilized by rice in both wet and dry season. Azolla can be used in two ways: 1) as green manure incorporated before transplanting, and 2) as an intercrop incorporated after transplanting. In each case, about 500-1000 kg (fresh weight) per ha is introduced into standing water in the rice field.

As Green Manure Incorporated Before Transplanting

The fields are flooded to a shallow depth, about 3-4 cm, and 'seeded' with Azolla at a rate of 500-1000 kg/ha. Fertilizer application of 2.2 kg Phosphorus (P)/ha every 5 days, 4 kg K/ha every 10 days, and 500−1000 kg/ha farmyard manure every 5−10 days is carried during the growth of Azolla in the field. When the field is covered with a mat of Azolla (about 20 ton/ha) and which usually takes about three weeks or more, the water is drained off and the Azolla ploughed into the soil. The incorporation of Azolla in the field supplies 30 to 60 kg N/ha. Rice is transplanted 2-3 days later.

As An Intercrop Incorporated After Transplanting

The other technique Azolla is applied in the paddy field after one week of transplanting. Azolla is of great agronomic value for rice crop where it is used as a dual crop with rice and contributes 40-60 kg N/haper rice crop.

Benefits

Azolla provides a variety of benefits for rice production and grows in a way that is complementary to rice cultivation:

- The thick Azolla mat in rice fields suppresses weeds and reduces ammonia volatilization.
- It fixes atmospheric nitrogen provides to the plant during its growth.
- After full vegetative growth of rice, Azolla begins to die and decompose due to low light intensities under the canopy and its nitrogen, phosphorus and other nutrients are rapidly

released into the water and made available for uptake by rice during grain development.

- In contrast with chemical nitrogenous fertilizers, Azolla has various positive long-term effects, including the improvement of soil fertility by increasing total nitrogen, organic carbon, plus phosphorus, potassium, other nutrients and organic matter.
- It enhances microbial population in the soil and improves the physical and chemical properties of the soil.
- Azolla contributes 40-60 kg N/ha per rice crop.

Conclusion

The continuous usages of chemical fertilizers have harmful effects on soil organic matter reserves, soil health and environmental safety and so there is an increasing concern about sustaining soil fertility and environmental health. The use of bio-fertilizers like Azolla increases rice productivity and also improves the long term soil fertility. Application of biofertilizer like Azolla could help effectively developing countries to improve more sustainable agriculture, without the risk of problems associated with the adverse effects of chemical fertilizers on long term soil fertility, soil productivity and environmental issues. It also improves the physical and chemical properties of the soil and enhances microbial population in the soil thereby maintains soil health.

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