

Super Plants” (Azolla) For Sustainable Rice Production

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ARTICLE ID: 065

Introduction:

Rice is an enormously important staple in many tropical and temperate regions of the world. Asian farmers produce about 90% of the total, with two countries, China and India, growing more than half the total crop. Nitrogen is the single most limiting factor in rice cultivation, strongly affecting the crop yield. Azolla substantially increases the amount of nitrogen fertilizer available to growing rice and it has been used for thousands of years as a ‘green’ nitrogen fertilizer to increase rice production. Bio fertilizers are the organism that enriches the nutrient quality of the soil. The main sources of bio fertilizers are bacteria, fungi and cyan bacteria. Azolla is water fern which is also used as a bio fertilizer. *Azolla pinnata*, a pteridophyte, is used as an excellent bio fertilizer in rice field.

Azolla – A super plant

It is a water fern having 2 surfaces of dorsal lobe and ventral lobe. Ventral side is brown in color, thin and dorsal side is green in color (Photosynthesis). *Anabaena azollae* present in the central cavity of azolla which has a symbiotic relationship with it. There are around 80,000 symbiotic cyan bacteria present on its leaves. This unique property has drawn the attention of agriculturists for its utilization in agriculture (Kamalasamana *et al.*, 2002). In view of an agronomist, it is used as bio fertilizers which increases organic matter, improves soil and supply fixed nitrogen, increases the uptake nutrient element such as Ca, Mg & K. It also helps to build up the micro-flora and in turn, the soil health. Azolla–anabaena relationship can fix almost three times more atmospheric nitrogen than legumes. Typical rates for legumes are 400 kg of nitrogen per hectare per year those for azolla-anabaena are 1100 kg of nitrogen per hectare per year.

Azolla Ecology:

Azolla is a highly productive plant. It doubles its biomass in 1.9 days or more, depending on conditions, and yield can reach 8–10 tonnes fresh matter/ha in Asian rice fields. 37.8 t fresh

weight/ha (2.78 t DM/ha dry weight) has been reported for *Azolla pinnata* in India. The daily nitrogen-fixing rate of the Azolla-algae (*Anabaena azollae*) complex is 3-7 kg N/ha. Azolla contains 4% nitrogen on a dry-weight basis (dry weight is 5% of fresh weight); 0.5-0.9% phosphorous; and 2-4.5% potassium. There are six species of Azolla viz., *Azolla Carolina*, *Azolla nilotica*, *Azolla filiculoids*, *Azolla mexicana*, *Azolla microphylla* and *Azolla pinnata*. The *Azolla pinnata* is a common species in India.

FACTORS	RANGE
Temperature	20°C - 25°C
Light	50% full sunlight
Relative Humidity	85 - 90%
Water	5 - 12 cm
pH	4-7
Salinity	90 -150 mg/litre

Environmental factors affecting the growth of a “Super Plant Azolla”

Importance as a fertilizer

It can increase the rice yield equivalent to that produced by 30-60 kg nitrogen (N) fertilizer/ha. Residual soil N is increased. Protein content of the grain is also increased. Azolla increases available potassium (K) by absorbing water-soluble K from the irrigation water and returning it into the soil upon incorporation. The large amount of biomass produced (10-15 tons/ha/incorporation) increases soil organic matter (OM) content dramatically, improving soil physical structure and increasing phosphorous availability. The OM from Azolla also contains micronutrients.

How to use azolla as fertilizer in rice fields

15 kg inoculums can multiply to become 10-15 tons of biomass in 100 days (provides 30-45 kg N/ha). About half of the total N is available in 3 weeks and 80% in 6 weeks. Incorporate the Azolla into the soil before transplanting and subsequent incorporations can be timed with the regular weeding operations. At any time, only 75% of the azolla is turned under. The remaining 25% is allowed to multiply again for the following incorporation.

Azolla increases rice productivity

Less than 5% of the nitrogen sequestered by azolla is available immediately to the growing rice plants. The remaining 95% remains in the azolla's biomass until the plant dies. When azolla is grown in paddies and then incorporated into the soil as green manure, its

nitrogen content is released upon decomposition and can be used by the crop. Azolla can replace at least 50% of the inorganic nitrogen requirement of rice. As the plant decomposes, its organic nitrogen is rapidly mineralized and released as ammonia, which then becomes available as a bio fertilizer for the growing rice plants (Samal *et al.*, 2020).

Experiments at the University of California at Davis showed that *Azolla* increased rice yields by 112% over unfertilized controls when applied as a mono-crop during the fallow season, by just 23% when applied as an intercrop with rice. However, the amount increased by 216% when *Azolla* was applied both as a mono-crop and an intercrop.

Benefits of incorporating azolla in rice cultivation

The thick azolla mat in rice fields suppresses weeds. Since azolla floats at the water surface, it does not compete with rice for light and space. In most climates, azolla grows best under a partial shade of vegetation which is provided by the rice canopy during early and intermediate stages of growth. When the rice approaches maturity, azolla begins to die and decompose due to low light intensities under the canopy and a depletion of nutrients, thus releasing its nutrients into the water. Because azolla decomposes rapidly, its nitrogen, phosphorus and other nutrients are rapidly released into the water and made available for uptake by rice during grain development. Azolla has a greater ability than rice to accumulate potassium in its tissues in low-potassium environments, providing rice with potassium after azolla's decomposition. When grown in a rice field, azolla reduces the ammonia volatilization that occurs following the application of inorganic nitrogen fertilizers by 20% to 50%. This is due to the fact that the azolla cover reduces light penetration into the floodwater, thus hindering the rise of pH which normally stimulates ammonia volatilization in an azolla-free rice field.

Other interesting facts about azolla

a) Larvicide - mosquito control:

Azolla can be used to control mosquitoes because a thick azolla mat on the water surface helps to prevent breeding and adult emergence. In a survey of pools, ponds, wells, rice fields, and drains, Ansari & Sharma (1991) found that breeding by *Anopheles* was almost completely suppressed in water bodies that were covered with azolla. Azolla extracts also have a larvicide effect over larvae of *Aedes aegypti* mosquito vectors.

b) Weed Control



The azolla cover reduced light intensity by about 90%, reducing photosynthesis in the floodwater and thus reducing oxygen concentration of the water by more than 50%. Besides reducing light intensity, an azolla cover alters light quality, the green leaves having a filter effect that increases the relative amount of infrared rays which reduces the germination of light-sensitive seeds.

c) Reduction of methane emission

Radha Prasana and a group of colleagues at various institutes in India have shown that methane production from rice growth is inhibited by the presence of azolla. This is relevant to reducing greenhouse gases (Prasana *et al.*, 2002). They investigated the role of *cyan bacteria* and azolla in methane production and oxidation in laboratory simulation experiments using soil samples from rice fields. All seven cyan bacterial strains that were tested and azolla produced a significant decrease in the headspace concentration of methane in flooded soil, incubated under light.

d) Removal of diesel contaminants & heavy metal

Azolla has the potential to biodegrade and remove diesel contaminants from soil and water. The diesel degradation was due to the release of bacteria (bio augmentation) and physiochemical improvement of the soil and water (bio stimulation). It can also be used to purify water polluted by metals and has potential applications for both industrial and mining operations, as well as space exploration.

e) Livestock feed

Azolla has enormous potential as a livestock feed due to its high content in proteins, essential amino acids, vitamins (vitamin A, vitamin B12, Beta Carotene), growth promoter intermediaries and minerals. It has been used for many years throughout Asia and parts of Africa to feed pigs, ducks, chickens, cattle, fish, sheep and goats and rabbits.

Conclusion

In the light of above facts, no wonder to quote the azolla as a “Super Plant”. Its usage over rice fields as bio fertilizer cum green manure pays way for sustainable rice production. It lowers the farmers input cost by minimizing the inorganic N fertilizers, herbicides and boost the farmers income. Application of azolla has been found to improve the physio-chemical & biological properties of the soil. These improvements were significant for nitrogen, organic

matter and other cations (Mg, Ca and Na) released into the soil. Careful management of soils in the tropics with azolla results in better production of crops since its production is cheap, economical and eco-friendly.

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