Azolla and its Potential in Organic Agriculture

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Azolla also known as mosquito fern, duckweed fern, fairy moss and water fern is a free floating small aquatic plant. The genus Azolla belongs to the single genus family *Azollaceae* which includes six species of *Azolla* viz., *A. caroliniana*, *A. nilotica*, *A. filiculoides*, *A. mexicana*, *A. microphylla* and *A. pinnata*. The most common species found in India is *A. pinnata* (Carrapiço *et al.* 2000). Azolla is one of the fastest growing plants on the planet which does not require soil to grow. The uniqueness of Azolla is in its symbiotic relationship with the nitrogen fixing blue green algae, *Anabaena azollae* which has often been considered as the perfect marriage where each partner gives something to this perfect marriage. The delicate fern provides nutrients and a protective leaf cavity for the *Anabaena*, which in turn provides nitrogen for the fern. Azolla is rich in crude protein, several amino acids, vitamins and minerals. Under suitable field conditions, the fern/alga combination can double in weight every 3 to 5 days and fix atmospheric nitrogen at a rate exceeding that of the legume/*Rhizobium* symbiotic relationship.

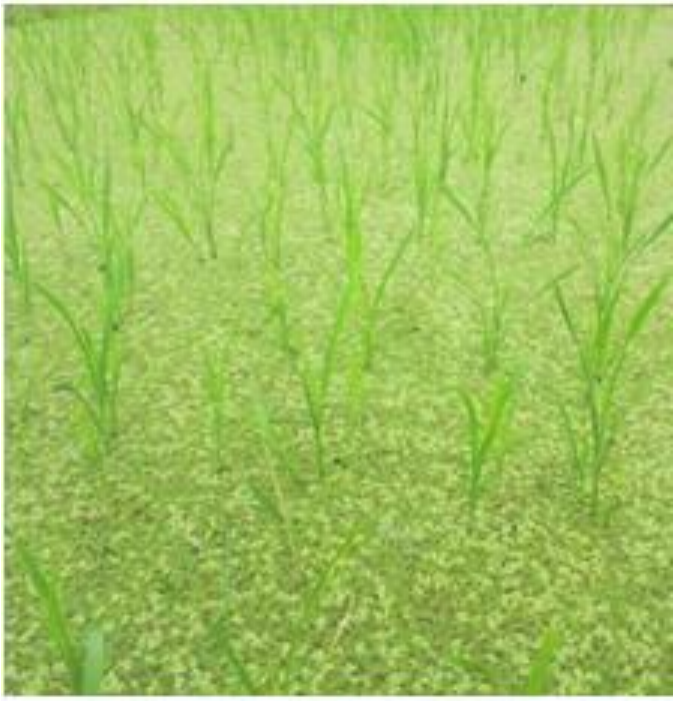

Fig: Dual culture of rice with azolla

Azolla can accumulate up to 2 to 4 kilograms of nitrogen/ha/day which is equivalent to 10 to 20 kg of ammonium sulphate. Azolla has tremendous potential in both crop production and livestock production. Apart from these uses, there is also a potential to utilize Azolla as a phytoremediator and sustainable bioenergy source. Some of the major benefits of Azolla are listed below:

i. Azolla is one of the promising biofertilizers for a variety of crops particularly rice due to its similar growth habit. Its application improves soil fertility by increasing total nitrogen, organic carbon, available phosphorus as well as many essential elements in the soil.

ii. Azolla contains many essential amino acids, vitamins (vitamin A, vitamin B_{12}, and beta-carotene), growth promoter intermediaries, and minerals like calcium, phosphorous, potassium, ferrous, copper, and magnesium. Therefore, it is also a very good feed for a variety of animals, including pigs, rabbits, chickens, ducks, and fish.

iii. It suppresses the growth of aquatic weeds by blocking sunlight and by providing a physical resistance to weed seedling emergence through a heavy interlocking azolla mat.

iv. It can also be used in the control of mosquitoes, for a thick Azolla mat on the water surface can prevent breeding and adult emergence.

v. It plays an important role towards ecosystem management including bioremediation of toxic trace metals and organic pollutants. It can act as a bio filter to remove pollutants. Azolla live biomass acts as potential bio accumulator for toxic pollutants, while the dead biomass regulates pollutant concentration through bio sorption.

vi. Its application can minimize greenhouse gas (GHG) emission from agriculture as well as mitigate atmospheric GHGs.

Utilization of Azolla in crop production

Azolla forms the most potential farm grown input in rice cultivation because of the similar growing condition. Azolla can be applied in rice field through two methods, *viz.* as a green manure crop or as a dual crop. Azolla grown along with rice do not decrease/effect the yield of rice. The nitrogen accumulated in the Azolla biomass is made available to rice crop after decomposition. It also adds to the organic matter content of the soil narrowing the C:N ratio. According to Susan and Kaleeswari (2015), the integrated use of 150:50:50 kg N, P_2O_5 , K_2O + 25 kg $ZnSO_4$ ha^{-1} through inorganic sources +*Sesbania aculeata*@ 6.25 t ha^{-1} + Azolla @ 500 kg ha^{-1} recorded the highest grain and straw yield of wet land rice and the highest uptake of N, P and K by grain and straw. The higher grain yield under integrated nutrient management treatments could be attributed to the combined effect of nutrient supply synergism and improvement in physical and biological properties of soil. Overall, using Azolla as a surface cover in combination with urea can be an alternative management practice worth considering as a means to reduce NH_3 volatilization and improve N use efficiency as well as rice yields (de Macale and Vlek 2004).

Field experiments were conducted at Indian Agricultural Research Institute, New Delhi during 2003-2009 to find out suitable organic amendments for sustainable productivity of Basmati rice-wheat-green gram cropping system (Singh *et al.*, 2011). Different treatment combinations comprising of organic amendments such as Azolla @1.0 ton ha^{-1}, Blue Green Algae @ 2.0 kg ha^{-1}, vermicompost and farm yard manure @ 5.0 ton ha^{-1} applied alone or in combination were tested. Results revealed significant enhancement in grain yield of rice over absolute control due to the application of organic amendments like Azolla applied alone or in combination. Optimum yield of Basmati rice (cv. Pusa Basmati 1) can be obtained in all the years with the application of four amendments (Azolla, BGA, vermicompost and FYM) together. Besides, enhancing and sustaining the productivity of organic rice-wheat system, higher productivity of vegetables like cauliflower, broccoli, cabbage and carrot grown after organic rice under organic nutrition were recorded (Singh *et al.*, 2012).

Azolla grown as a monocrop between the wheat and rice crops or applied as an intercrop with rice has a significant beneficial effect on subsequent wheat crops in rice-wheat cropping system. In the case of bananas, Azolla is applied as mulch on the soil surface around the bases of the plants. When there is an overproduction of Azolla, it can be mixed with rice straw to form compost. Incorporation of 6–24 t ha^{-1} of fresh Azolla into the soil significantly increased its water-holding capacity, organic carbon, ammonium-N, nitrate-N, and its available phosphorus, potassium, calcium, and magnesium,

while it decreased pH and bulk density. Azolla used as a green manure significantly raised the yield of mungbean (Nuraisyah 2002).

Conclusion

The application of Azolla as a biofertilizer on agricultural crops, reducing or replacing chemical fertilizers, can play a significant role in maintaining or improving ecological balance. Utilization of Azolla in agriculture also improves social economic status by reducing the agricultural input cost, generating employment opportunities for small-scale industry involved in its propagation. Thus, it can be concluded that Azolla has tremendous potential for replacing chemical fertilizers in organic as well as natural farming.

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