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Beneficial effects of Blue- Green Algae and *Azolla* in rice culture

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Abstract

Pot experiments were conducted to evaluate the potentiality of *Azolla* and Blue Green Algae as biofertilizers for rice productivity. Blue Green Algae inoculation increased grain yield by 15% and straw yield by11%, *Azolla* showed increment by 26% in grain yield and by 20% in straw yield. *Azolla*and Blue Green Algae showed considerable increased in the N-content of soil, grain and straw. *Azolla* double incorporation was found more effective than other methods of application.

Keywords:*Biofertilizer, Blue-Green Algae, Azolla, Rice*

Introduction

Intensive agriculture based on synthetic inputs popularly known as "Green Revolution" has practically replaced our traditional natural renewable resource based agriculture in over last 40 years. Although, the initial results of this technology was very exciting and resulted into four fold increase in production but all this success has come on the cost of future generations and our environment. Biotechnological harvesting of microbial potential in nutrient mobilization and plant protection is one of the widely acclaimed options, which suits both the requirement of optimum production and environment sustainability. Use of microbial system for nutrients mobilization, popularly known as biofertilizers are getting popular day by day and new systems are being introduced to meet our requirements of different crops and under different cropping systems. Rice (*Oryza sativa*) is the major food crop of nearly half of the world's population. It is the most important crop of India and it fulfills 31% of calorie requirement of Indian population. In India rice is cultivated in 44.0 million hectors (mha) of land and it contributes 43 and 46% of the total food grain and cereal production, respectively. Among the rice growing countries of the world, India has the largest area under rice; however it stands second next to China on its production (FAOSTAT, Database, 2007).Generally, urea is applied as nitrogen source for rice production. But the efficiency of added urea-N is very low, often only 30-40% (Singh, 1988; Choudhary*et al*., 2002). This low N-use efficiency is mainly due to denitrification, NH_3 volatilization and leaching losses(Ponnamperuma, 1972: De Datta and Buresh**,**1989)**.**NH_3 volatilization and denitrify-cation cause atmospheric pollution through the production of green-house gases like N_2O and NH_3 (Reeves *et al*., 2002). NH_3 leaching also ground water toxicity (Shrestha and Ladha, 1998). In addition to these environmental problems, the long-term use of urea might deplete soil organic matter. These problems are of great concern to soil and environmental scientists around the world. Hence, alternate sources of nitrogen should be applied to minimize these problems. Biological nitrogen fixation (BNF) technology can play an important role in substituting for commercially available nitrogen fertilizer used in rice cultivation.

Biological nitrogen fixers like *Azolla*and cyanobacteria can be the ultimate solution for proper rice production. *Azolla* commonly known water velvet is a small delicate free floating fern. *Azolla* is a genus of *Leptosporangiata*, an aquatic fern that harbors a heterocyst forming, nitrogen fixing blue-green alga, *Anabaena azolla*e as a symbiotic in the dorsal lobe cavity. *Azolla* in

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symbiosis with the cyano bacterium *Anabaena azolla*e fixes substantial amounts of nitrogen and isof great agronomic significance (Roger and Kulasooriya, 1980; Watanabe, 1984; Singh, 1977, 1985, 1989).Cyanobacteria or Blue-Green algae (BGA) are photosynthetic prokaryotic micro-rganism capable of fixing atmospheric nitrogen (N_2) using sunlight as the sole energy source. BGA are distributed worldwide and contribute to soil fertility in many agricultural ecosystems. BGA can adapt to various soil types and environments which have made it cosmopolitan in distribution. The importance of BGA in nitrogen nutrition of rice has earlier been reported by various workers (Singh, 1961; Singh, 1985;Venkataraman, 1972; Singh and Bisoyi, 1989; Kaushik, 1990).Efficient nitrogen fixing strains like *Nostoclinkia, Anabaena variabilis*,*Aulosirafertilisma*,*Calothrix*sp.,*Tolypothrix*sp.and *Sytonema*sp. were identified from various agro-ecological regions and were utilized for rice production (Roger and Ladha, 1992; Singh, 1988; Kannaiyan*et al*., 1997; Kennedy and Islam, 2001). *Azolla*and BGA both have been reported to be effective in improving the organic content of soil, phosphorus availability in soil as well as improve the physical properties of soil (Mandal*et al*., 1999; Singh *et al*., 1981). In the present study an attempt has been made to evaluate the potential of *Azolla* and cyanobacteria as bio fertilizer for rice production.

Materialsand Method

Pot experiments were conducted at the Institute of Agricultural Sciences, Banaras Hindu University (BHU) Varanasi, India. The seed of rice variety (Mahsuri 3022) were procured from Agriculture farm of B.H.U. A mixture of blue-green algal strains (*Aulosira*,*Nostoc, Anabaena*,*Gleotrichia*) were collected from the rice fields and after identification and purification they were used for large scale production. The BGA grown in small tanks under field conditions were used as bio fertilizer inocula.

Azollapinnata, a dominant strain of *Azolla* available in the rice field (which can with stand high temperature) was also collected and produced in mass in the clay pot.Soil was collected from the local areas Amrakhaira, Vidyapeeth, Block, Varanasi, from top 30 cm of the fields were thoroughly mixed, sieved and part of the soil was used for physico-chemical analysis; determination of pH (at 1:2 soil water ratio) by Systronicsexpanded Scale pH meter, total nitrogen by modified kjeldahl method (Jackson, 1973). Organic Carbon was analysed by Walkley and Black's Method (Jackson, 1967). Urea and single super phosphate (SSP) were used as mineral fertilizer in the experiments. Soil was alkaline (pH-8.8) with low nitrogen (0.003%).Pot experiment contained seven treatments with three replications. The treatments were:

T_1 – Control, T_2 - BGA inoculation, T_3 – NPK, T_4 – *Azolla* inoculation, T_5 – *Azolla* incorporation before transplantation, T_6 – *Azolla* incorporation after transplantation, T_7 – *Azolla* double incorporation.Five seedlings of twenty days old seedling of the rice variety Mashuri 3022 were transplanted in each pot containing 8 kg of soil. *Azolla* was applied @ 2t/ha in the pot. BGA inoculum was applied @ 400 g/acre. Nitrogen was applied in two splits, half nitrogen as basal dose and other half nitrogen as top dressing. The data required for yield attributes were taken before harvest and that for yield was taken after harvest.

Results and Discussion

In the pot experiments, all the treatments have shown better performance than the control (Table-2). Highest grain yield (11.0 g/pot) was supported by NPK treatment which was almost equal to that of *Azolla* double incorporation (10.8g/pot). Straw yield was found maximum in NPK treated pots (T_3). BGA inoculation (T_2) increased the grain and straw yield by 9 and 10% respectively. In the pot experiment *Azolla* was utilized in four different ways. Among them *Azolla* double incorporation (T_7) supported highest grain yield (26%) while highest increase (21%) in the straw yield was recorded in the pots where *Azolla* incorporation was followed by inoculation (T_6). The result in the table clearly reveals that the least nitrogen content was found in the soil and plant materials of the control set (Table-3). Whereas maximum nitrogen in the grain was recorded in NPK treated pots (T_3) while it was maximally recorded in soil and straw in *Azolla* double incorporation pots (T_7).The poor yield in the control set might be attributed to the unavailability of sufficient nutrient to the control set (Table-2). High grain yield by *Azolla* inoculation could possibly be due to the good cover and nitrogen supply by *Azolla*. However, comparatively low straw yield might be due to the hindrance in the growth of plant due to thick *Azolla*cover. The better grain yield and relatively low straw yield could also be explained on the basis of slow release of nitrogen by *Azolla*, thus rice plants at its early stage do not get sufficient nitrogen which is essential for better vegetative growth. Our results are also supported by Watanabe *etal*. (1997), where slow release of nitrogen by *Azolla* is accounting for better grain yield. Interestingly, *Azolla* double incorporation gave better yield than on its inoculation which could simply be due to the additional supply of nitrogen to the crop (Table-2). Better results by *Azolla*incorporation than inoculation have also been reported by (Singh, 1988) and Watanabe *et al*. (1997). Our findings are also supported by Singh and Singh (1986).

Table-1: Physico–Chemical properties of the soil collected from Khaira, Varanasi

S. No	Parameters	Control Soil
1	Temp (^{0}C)	36.6
2	Moisture (%)	3.62
3	W.H.C. (%)	22.4
4	pH	8.8
5	OrganicCarbon (%)	0.03
6	Organic matter (%)	0.051
7	Total Nitrogen(%)	0.003
8	C:N	10.0
9	E.C. (dsm-1)	0.86

Table-2: Effect of biofertilizers on the yield and yield attributes of rice

S. No	Treatments	Plant height (cm)	Panicles/ Pot	Weight of 1000 Grains (g)	No. of Grains/Panicle	Grain Yield (g/Pot)	% Increase	Straw Yield (g/Pot)	% Increase
1	T_1	68.2	4.7	21.8	91.4	8.6	100	10.7	100
2	T_2	74.2	4.7	22.3	98.6	9.4	109.3	11.8	110.3
3	T_3	78.6	6.3	22.8	115.2	11.0	127.9	14.4	134.6
4	T_4	76.7	4.7	22.4	100.6	10	116.3	12.3	115
5	T_5	75.0	4.7	22.1	95.6	8.9	103.5	10.9	101.9
6	T_6	77.1	5.0	22.7	110.2	10.2	118.6	12.9	120.6
7	T_7	77.0	5.0	23.2	109.2	10.8	125.6	12.8	119.5

Statistically significant 5%

Table-3: Effect of biofertilizers in the nitrogen content in rice

S. No	Treatments	Total Nitrogen Content (t/ha)		
		Soil	**Grain**	**Straw**
1	T_1	4.2	22.4	20.2
2	T_2	4.4	23.8	20.8
3	T_3	5.2	25.0	25.8
4	T_4	5.4	28.0	23.0
5	T_5	4.4	22.6	20.6
6	T_6	5.6	27.0	25.2
7	T_7	6.0	27.6	26.0
	F-test (5%)	Ns	*	*

***Statistically significant 5%**
NsStatisticallyinsignticant 5%

However, the percent of increment varied from the increase reported by Manna and Singh (1990), which could be due to the difference in the rice variety used, climatic and soil conditions and the difference in the amount of *Azolla*inoculated.The better grain and straw yield by split application was due to the availability of nitrogen to the rice at the early stage as well as the later stages of growth. Similar results were also reported by Whitton and Roger (1989) and Saha (1981), Singh (2010). Where basal dose of nitrogen is utilized for the vegetative growth and the nitrogen supplied as top dressing at the later stages of plant growth is utilized in panicle formation which accounts for higher grain yield. Comparatively poor performance by BGA could be due to their inability to colonize in the climate condition. Singh and Singh (1986) reported that BGA established itself in 40 days after transplantation (DAT) and then increased in biomass till harvest which might be the cause of low straw yield, while *Azolla* established itself within 30 DAT and then started decomposing and thus releasing nutrients to soil and water earlier. Increase in the nitrogen content of soil and plant material has been reported by many workers. Whitton (2000) reported considerable increase in the nitrogen content of soil incorporated with *Azolla*. Similarly, Singh *et al*. (1981) reported increase in nitrogen uptake by grain straw as well as nitrogen content in soil. They found *Azolla* more effective than BGA as more nitrogen was supplied by *Azolla* due to its fast decomposing property.

Conclusion

The use of *Azollapinnata*and BGA results better yield and improves the nitrogen in rice by biological nitrogen fixation.Overall it can be concluded that *Azollapinnata* can be used an alternative source of nitrogen in transplanted rice. *Azolla* are grown before and after planting rice, fixed sufficient nitrogen to meet the requirement of the rice crop.BGA however, could only replace 30kg Nha^{-1} supplied as urea. Thus *Azolla* can be recommended to rice growers as alternative source of nitrogen and BGA could only be used when supplemented with additional chemical nitrogen fertilizer in order to meet the total nitrogen demand of the rice. Thus *Azolla* and BGA can become an eco-friendly, cost-effective, renewable source of nitrogen to the flooded rice which can results better yield and sustainable agriculture in long-run.

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