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RESEARCH ARTICLE

DISTRIBUTION OF CYANOBACTERIA (BLUE-GREEN ALGAE) IN RICE FIELDS OF VARANASI

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Abstract

Cyanobacteria are the most important nitrogen fixing organism because of their autotrophic nutrition and flourish in rice fields and known to sustain the fertility of this ecosystem. The paddy field ecosystem provides a favorable environment for the growth of cyanobacteria with respect to their requirement for light, water, temperature and nutrient availability. Cyanobacteria play an important role in maintenance and build-up of soil fertility, consequently increase rice growth and yield as a natural biofertilizer. In respect to their role in increasing the fertility of rice soils cyanobacteria are of the special academic and applied interest. We survey and studied four different paddy fields of Varanasi namely Lakshmanpur, Ramnagar, Tarana and Sarnath for studying the cyanobacteria biodiversity. These paddy fields mainly comprises heterocystous and non-heterocystous blue-green algae. In the begning of rice crop *Microcoleus sociatus*, *Lyngbya major, Phormidium truncicola* and *Oscillatoria subbrevis* has been seen. In the middle of rice crop *Oscillatoria subbrevis, Nostoc muscorum, Anabaena oryzae, A. doliolum, Cylindrospermum sphericum* has been seen. At the maturity of rice crop luxurious growth of *Nostoc muscorum*, *Anabaena doliolum, Cylindrospermum stagnale* and *Haplosiphon welwitschii* have been found.

INTRODUCTION

Blue green algae possess an autotrophic mode of growth like eukaryotic plant cells, metabolic system like bacteria and occupy a unique position. They possess chlorophyll ‘a’ and are gram negative which carry out oxygenic photosynthesis. They exhibit a great morphological diversity and their broad spectrum of physiological properties reflects their widespread distribution and tolerance to environmental stress. (Tandeau de Marsac and Howard, 1993). Several reports have indicated a widespread distribution of forms like *Oscillatoria, Nostoc, Anabaena, Phormidium* and *Aphanothece* (Gupta, 1975; Sinha and Mukherjee, 1975; Paul and Santra, 1982). The dominating heterocystous nitrogen fixing blue green algal species of *Aluosira, Cylindrospermum, Nostoc, Anabaena, Tolypothrix* and *Calothrix* were reported from soils of Cuttack and Orissa (Singh, 1961). Studies on the cyanobacterial diversity have gained much importance especially after the recognition of their role in the natural environment and their ability to provide an alternate source of energy. Moreover they form simple model system for understanding of various basic phenomenon such as cellular metabolism synthesis of macro molecular compounds, cell differentiation and regulation of gene expression. The capability of several cyanobacteria to fix the atmospheric nitrogen is a significant biological process (Sanctra , 1993). Rice (*Oryzae sativa* L.) is one of the most prominent food crops globally, and represent the staple diet for almost half of the human population of the world which accounts for 23% of the world’s calorie intake (Bernier *et al.* 2008). Cyanobacteria are known to liberate a wide array of extracellular substance e.g. Plant growth regulators vitamins, amino acids, sugars and other metabolites which have direct or indirect impact on

plant growth and yields (Mandal *et al*. 1999; Prasanna *et al*. 2008). Besides their well established role as nitrogen supplements and tolerance to desiccation, cyanobacteria can be key players in carbon sequestration and improving nutrient use efficiency and crop yields (Watanabe and Yamamoto 1971; Rao and Burns 1990).
The paddy field ecosystem consists of diverse habitats for microorganism. These habitats are microenvironment physico - chemically different to each other and could exihibits biologically distinct properties. Such heterogeneity of the habitat should influence the structure and diversity of microbial communities in the paddy field ecosystem as a whole and may support various microbiological process occurring in paddy fields which are agronomically and biogeochemically important (Kimura, 2000; Kirk, 2004). The abundance of cyanobacteria in paddy fields was first observed by Fritsch (1907). BGA inoculation popularly known as “Algalization” helps to provide an environmentally safe agro-ecosystem contributing to economic viability in paddy cultivation, reducing cost and energy inputs (Sunil Pabbi, 2008). The aim of this study was to investigate the diversity of the indigenous blue green assemblage in the paddy field and also to follow the seasonal changes in the population during the rice growth season and after harvest. The ability of cyanobacteria to fix atmospheric nitrogen is increasing concern worldwide to exploit this tiny living system for nitrogenous fertilizers for sustainable agricultural practices.

MATERIAL AND METHODS

Site selection: Sites were selected in four parts of Varanasi district. Site 1st was Laxmanpur, Site 2nd was Ramnagar, Site 3rd was Tarana and Site 4th was Sarnath. In each part, rice fields were used as sampling sites.

Collection of Cyanobacteria samples and identification of strains

Moist cultures of soil algae were prepared by spreading a layer of soil (about 1 cm thick) and moistered with sterilized distilled water periodically in petridish covered with a sheet of glass both previously sterilized (John 1942). In about a fortnight after incubation, the visible growth of algae appear in the culture. One of the replicates was disturbed for microscopic examination while others were left undisturbed for further observation.

For making unialgal culture, few drops of the culture or cells of the algal flora were drawn into the fine pipette was led in sterilized distilled water and transferred to solid agar plates after 10-15 days. Petridishes were observed for algal colonies, such colonies were then transferred into various nutrients media for their isolation and identification.

RESULTS

In the present study seasonal variation in the Cyanobacterial population has been reported from the paddy fields from July 2013-December 2013. The cyanobacterial strains were isolated from different paddy fields. We have also investigated the biodiversity of cyanobacterial population. We study the cyanobacterial diversity from July to December (during cultivation period of rice). We observed that in the end of July and beginning of August some non-heterocystous Blue-green algae like *Microcoleus sociatus*, *Lyngbya major*, *Phormidium truncicola* and *Oscillatoria subbrevis* has been appeared. In the month of August non- heterocystous and heterocystous cyanobacteria like *Oscillatoria subbrevis, Nostoc muscorum*, *Anabaena oryzae*, *A. doliolum*, *Cylindrospermum spharica* has been seen. In the month of September and October(maturity of rice crop) luxurious growth of *Nostoc muscorum*, *Anabaena doliolum*, *Cylindrospermum stagnale, Haplosiphon welwitschii* and *Scytonema sp*. have been found. After harvesting (Nov. and Dec), during the later part of cyanobacterial growth some non- fixers such as *Phormidium* and *Microcoleus* were intermingled with diazotrophic forms.

Identification of Taxa:

The blue-green algal species has been identified following the criteria given in a monograph of Cyanophyta (Desikacharya-1959). The common blue-green algae which grew in rice fields were the species of *Microcoleus, Lyngbya, Oscillatoria, Cylindrospermum, Nostoc*, *Scytonema* and *Haplosiphon.*

Table-1 Distribution pattern of Cyanobacterial species at different sites of Varanasi

S.N.	Algae & Cyanobacteria	Site 1	Site 2	Site 3	Site 4
1.	Oscillatoria sancta	+	-	+	+
2.	Oscillatoria subbrevis	+	+	+	+
3.	Oscillatoria princeps	+	+	+	-
4.	Oscillatoria acuta	+	+	+	+
5.	Phormidium truncicola	+	-	+	+
6.	Phormidium ambiguum	-	-	+	-
7.	Phormidium oryzetorum	+	+	-	+
8.	Lyngbya laxespirialis	+	-	+	+
9.	Lyngbya lagerheimii	+	+	-	-

10	Lyngbya truncicola	-	+	+	+
11.	Lyngbya major	+	+	+	+
12.	Microcoleus paludosus	-	+	-	+
13.	Microcoleus sociatus	-	+	-	+
14.	Cylindrospermum sphaerica	+	-	+	+
15.	Cylindrospermum staganale	-	-	+	+
16.	Cylindrospermum musicola	-	-	+	-
17.	Nostoc calcicola	+	+	-	+
18.	Nostoc muscorum	+	+	+	-
19.	Nostoc commune	+	-	+	-
20.	Anabaena oryzae	+	-	+	-
21.	Anabaena doliolum	+	+	-	+
22.	Anabaena variabilis	+	-	+	-
23.	Scytonema bohneri	-	-	+	-
24.	Scytonema hofmanni	-	-	+	-
25.	Scytonema coactile	-	+	+	-
26.	Spirulina subsalsa	+	-	-	-
27.	Calothrix castellii	+	+	+	+
28.	Calothrix marchica	+	-	-	+
29.	Gleotrichia ghosei	-	+	+	-
30.	Gleotrichia natans	+	-	-	+
31.	Haplosiphon welwitschii	+	-	+	-
32.	Haplosiphon fontinalis	-	-	+	-
	Total number	**21**	**15**	**23**	17

+ Present, - Absent

Table-2 Chemical properties of rice field soils at different locations.

Season	Beginning of rice crop				Middle of rice crop				After harvest			
Location	Site1	Site2	Site3	Site4	Site1	Site2	Site3	Site4	Site1	Site2	Site3	Site4
P^H	7.51	7.25	7.58	7.65	7.67	7.86	7.89	7.46	7.50	7.28	7.97	7.55
EC	2.10	2.04	2.14	2.13	3.98	3.93	3.83	3.90	3.98	3.49	4.00	3.99

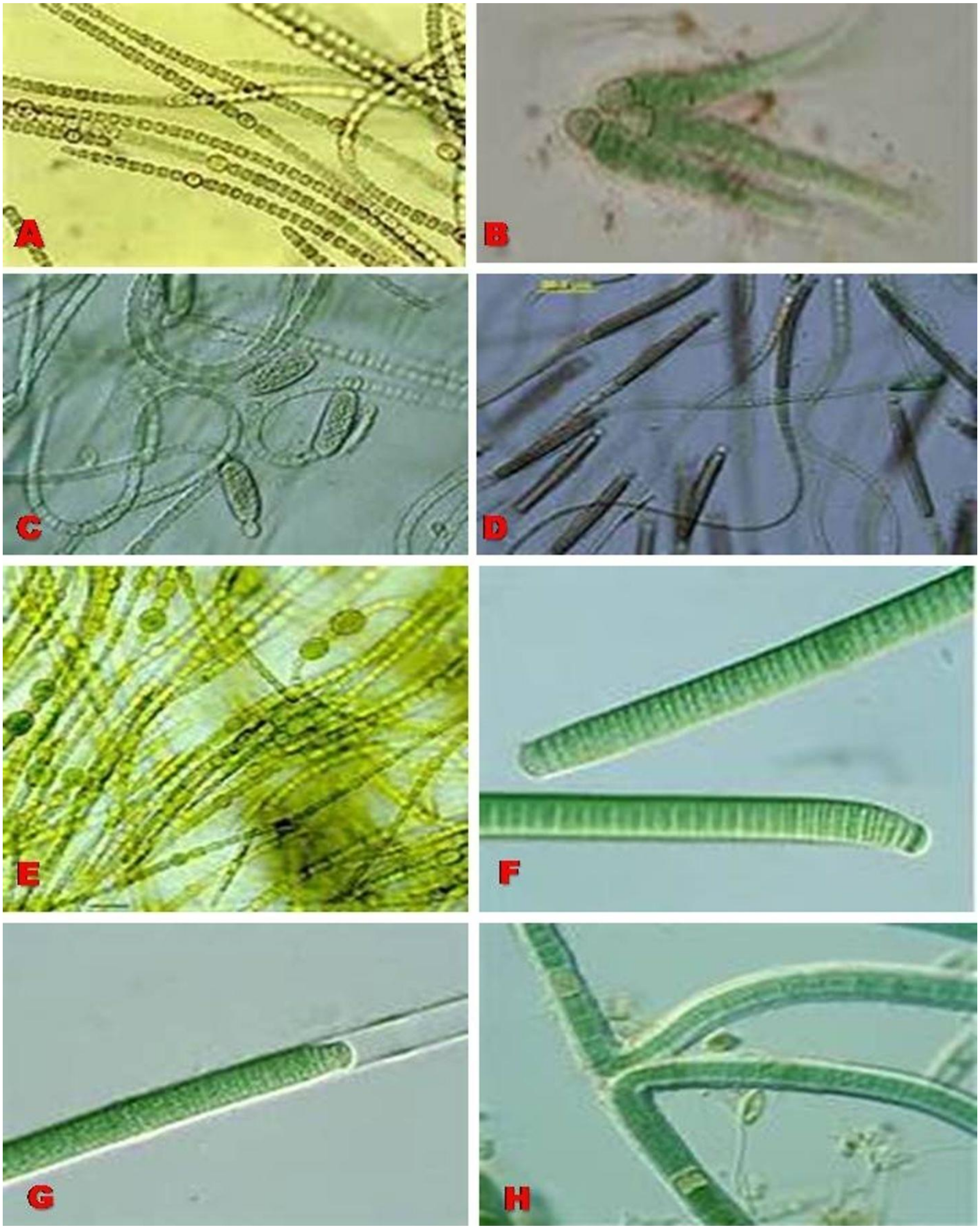

Fig. 1 A. *Anbaena variabilis*, B. *Calothrix sps* C. *Cylindrospermum muscicola* D. *Gleotrichia natans* E. *Nostoc muscorum* F. *Oscillatoria princeps* G. *Phomidium ambiguum* H. *Scytonema bohneri*

DISCUSSION

Rice fields are temporary wetland ecosystems, with variable biodiversity and cyanobacteria are known to be an integral component of waterlogged rice fields. The rice field ecosystems with its optimum levels of light, water, temperature, humidity and nutrient availability provide a favourable environment for the luxuriant growth of cyanobacteria. The favourable balance of soil nitrogen of rice fields wherein rice can be grown on the same land even without any addition of fertilizers and without any reduction in yield, confirms to the significance of cyanobacterial nitrogen fixation (Venkatraman, 1972; Nayak *et al*., 2001; Nayak *et al*., 2004; Song *et al*., 2005). It is also a well known fact that besides contributing to soil nitrogen and improvement in yield of rice, cyanobacteria also produces agronomically significant changes in the physical, chemical and biological properties of soil and soil-water interface of rice fields (Mandal *et al*., 1998; Nayak *et al*., 2004). Cyanobacteria play an important role in maintenance and build-up of soil fertility, consequently increase rice growth and yield as a natural biofertilizer (Song *et al*. 2005).

The paddy field ecosystem provides a favourable environment for the growth of cyanobacteria with respect to their requirements for light, water, high temperature and nutrient availability. This could be the reason for more abundant cyanobacteria growth in paddy soils than in upland soils (Roger and Reynaud 1982, Kondo and Yasuda, 2003). Among four sites, site 3 (Tarana) exhibited the maximum number of cyanobacteria and the minimum at the site 2 (Ramnagar). More than half of cyanobacterial species were N_2-fixing. Cyanobacterial population exhibit rapid quantitative variation along the cultivation cycle. The heterocystous cyanobacterial strains were significantly higher in months of October. Among heterocystous genus *Nostoc* was most abundant, followed by *Anabaena* in all the sites where as *Oscillatoria* found in most abundant form in early days of rice cultivation cycle. The gradual increase in diversity of N_2 fixing cyanobacteria with progress in paddy cultivation was assumed to be related with increase in rice canopy that causes a decrease in light intensity reaching to the surface of the soil and depletion of nutrients particularly nitrogen. The distribution of these blue green algal forms might be indicating the lower nitrogen status in rice fields.

Among different chemical properties pH is important in determining growth ,establishment and diversity of cyanobacterial flora, which is generally been reported to prefer neutral to slightly alkaline (Roger and Kulasooriya 1980, Kaushik 1994). In our study a high positive correlation is observed between the soil pH and cyanobacterial population. The pH of site 3 (Tarana) was higher than other than 3 sites at this site the cyanobacterial population was also high.

In conclusion, the present study documented a remarkable biodiversity of blue green algae. *Anabaena* was the dominant genus of soil micro flora in the rice fields of studied area. The favourable balance of soil nitrogen of rice fields where in rice can be grown in the same rice field without any addition of fertilizers and without any reduction in yield, confirms the significance of nitrogen fixation by blue green algae. Cyanobacteria benefits in rice plants by producing growth promoting substances followed by increasing the availability of phosphorus by excretion of organic acids was also exploited in the prevention of soil erosion process (Kumar and Rao, 2012). Blue green algae are one of the major components of the nitrogen fixing biomass in the rice fields. Finally, it might be concluded that the documentation on cyanobacteria may enhance the understanding of the nutrient status of the field and might be applied for sustainable agricultural practices by reducing the application of chemical fertilizer to avoid the appearance of non-nitrogen fixers in the soil that might compete with nitrogen fixers for nutrients (Song *et al*,2005; Agawin *et al*, 2007).

On the basis of field and laboratory observation we can concluded that most cyanobacterial population were found in September. At this time, the field was submerged with approximately 10 cm water and the light intensity at the soil surface was low due to the rice canapy. In contrast, in November and December (after haevest) when the soil was dry and the surface exposed to full sunlight, the number of different cyanobacteria decline. This change indicate that water availability, light intensity and temperature are important and might be the main factors regulating the cyanobacterial population.

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REFERENCES

Agawin, N.S.R., Rabouille, S., Veldhuis, M.J.W., Servatius, L.,Hol, S., van Overzee, H.M.J., Huisman, J. 2007. Competitionand facilitation between unicellular nitrogen-fixing cyanobacteria and non-nitrogen-fixing phytoplanktonspecies. Limnol. Oceanogr. 52(5): 2233-2248.

Bernier J,Atlin GN,Serraj R,Kumar A,Spaner D. 2008. Breeding upland rice for drought resistance.J Sci Food Agric 88:927-939

Desikachary,T.V. 1959. Cyanophyta, Indian Council of Agricultural Research.New Delhi.pp 700.

Fritsch F.E. 1907. The sub aerial and fresh water algal flora of the tropics. Annals of Botany 30:235-275.

Gupta, D. 1975. Some new records of blue green algae from West Bengal. *Bulletin of Botanical Society of Bengal*.19:1-2.

Kaushik, B.D. 1994. Algalization of rice in salt-affected soils. – Annals of Agricultural Research 14: 105-106.

Kimura, M. 2000. Anaerobic microbiology in waterlogged rice fields. In: Bollag, J.M., Stotzky, G. (Eds.), Soil Biochemistry, vol. 10. Marcel Dekker, New York, pp. 35–138.

Kirk, G. 2004. The Biogeochemistry of Submerged Soils. Wiley, Chichester, 291pp.

Kondo M., Yasuda M. 2003. Seasonal changes in N_2 fixation activity and N- enrichment in paddy soils as affected by soil management in the northern area of Japan.Japan Agricultural Research Quarterly,37:105-111.

Kumar, S. R. S. and Rao, K. V. B. 2012. Biological nitrogen fixation: A Review. Int. J. Adv. Life Sci; 1:1-6.

Mandal, B., Vlek, P.L.G., Mandal. L.N. 1998. Beneficial effect of blue green algae and *Azolla* excluding supplying nitrogen, on wetland rice fields: a review. – Biology and Fertility of Soils 27: 329-342.

Mandal, B., Vlek, P.L.G., Mandal. L.N. 1999. Beneficial effect of blue green algae and *Azolla* excluding supplying nitrogen, on wetland rice fields: a review. – Biology and Fertility of Soils 28: 329-342

Nayak, S., Prasanna, R., Dominic, T.K., Singh, P.K. 2001. Floristic abundance and relative distribution of different cyanobacterial genera in rice field soil at different crop growth stages. Phykos.40:14-21

Nayak, S., Prasanna, R., Dominic, T.K., Singh, P.K. 2004. Effect of BGA- *Azolla* biofertilizers on nitrogen fixation and chlorophyll accumulation at different depths in soil cores. – *Biology and Fertility of Soils*. 40: 67-72.

Paul,T.K. and Santra S.C. 1982. Contribution to the cyanophyceae of Murashidabad.Phykos.21:150-152

Rao, D.L.N., Burns, R.G.1990. The effect of surface growth of blue green algae and bryophytes on some microbiological biochemical and physical soil properties.Biol Fertil Soils 9:239-244

Roger, P.A. and Kulasooriya 1980. Blue-Green Algae and Rice. IRRI, Philippines Manila.

Roger, P.A., Renaud P.A. 1982. Free Living Blue-Green Algae in Tropical Soils. Martinus Nijhoff Publisher La Hague.

Santra,S.C. 1993. Biology of rice fields blue green algae. Daya Publishing House ,Delhi.

Singh, R.N. 1961. Role of blue-green algae in nitrogen economy of Indian agriculture. – Indian Council of Agricultural Research, New Delhi.

Song.T., L.Martensson,T.Eriksson,W.Zheng and U.Rasmussen. 2005. Biodiversity and seasonal variation of the cyanobacterial assemblage in a rice paddy field in Fujian,China.FEMS Microbiology Ecology.54:131-140.

Tandeau de Marsac and J. Howard 1993. Adaptation of cyanobacteria to environmental stimuli: new steps to the worlds molecular mechanism. FEMS. Microbiological review.104:119-120

Venkataraman, G.S. 1972. Algal biofertilizers and rice cultivation. Today and Tomorrows publishers, Delhi.

Watanabe, A. and Yamamota 1971. Algal nitrogen fixation in the tropics. Plant soil, special vol.403-413