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Diversity and distribution of heterocystous nitrogen fixing cyanobacteria in the rice fields of Kamrup, Assam, India

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ABSTRACT

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Heterocystous nitrogen fixing cyanobacterial diversity and distribution were investigated in nine rice fields of Kamrup, which is one of the oldest landmasses of Brahmaputra flood plain of North East India. Rice is the staple crop of the region since times immemorial. The study was conducted from June 2010 to May 2011. A total of 49 heterocyst bearing cyanobacterial stains belonging to 6 families and 12 genera were identified. *Anabaena* with 15 species was the dominant genus followed by *Nostoc* (12 spp.). The other genera recorded were *Anabaenopsis* (1 sp.), *Aulosira* (4 spp.), *Cylindrospermum* (2 spp.), *Scytonema* (2 spp.), *Tolypothrix* (2 spp.), *Calothrix* (5 spp.), *Rivularia* (1 sp.), *Hapalosiphon* (3 spp.), *Mastigocladus* (1 sp.), *Mastigocladopsis* (1 sp.). Sorensen index revealed a little similarity among the fields in terms of cyanobacterial species composition.

Key-words: Nitrogen fixing cyanobacteria, diversity, distribution, rice fields, Kamrup District, Assam, India.

INTRODUCTION

Being situated on the lower Brahmaputra floodplain, the Kamrup region is exposed to recurring inundation during monsoon. The area is best suited for rice cultivation which is the staple food crop of the entire north-eastern India. About 90% of total population of Kamrup lives in rural areas and their potent occupation is agriculture. The consumption of chemical fertilizers in Kamrup is lower than that of the national standard of the country (Gopalakrishna 2000). This indicates dependency of the traditional farmers on natural fertilizer. Since the supplement of chemical nitrogen fertilizers is not a cost effective practice, the marginal farmers are unable to meet this high budgeted process. In addition, utilization of chemical fertilizers has posed a serious threat to soil quality, environment and sustainability of food grain production. It therefore becomes important to understand the soil microflora, with special reference to cyanobacteria, in order to suggest an alternate low cost and renewable source of nitrogen fertilizers for improving the carbon content of the soil to uplift rice production.

Cyanobacteria (BGA) are morphologically diverse and complex group of prokaryotic organisms. A few have the capacity to fix atmospheric nitrogen. Cyanobacteria are considered as natural biofertilizer for many years (Baftehchi et al. 2007). Representatives of the group are found abundantly in crop field ecosystems throughout the world (Whitton 2000). Besides maintaining the nitrogen status and fertility of soils, they are also responsible for improvement of the structure and physico-chemical characteristics of soils by increasing phosphorus content (Fuller & Rogers 1952) by secreting plant growth promoting substances

(Pandey et al. 2005, Zulpa et al. 2008) and also by enhancing water holding capacity that leads to reduce soil erosion (Richert et al. 2005). They act as potential agents for the biological control of plant pathogenic bacteria and fungi.

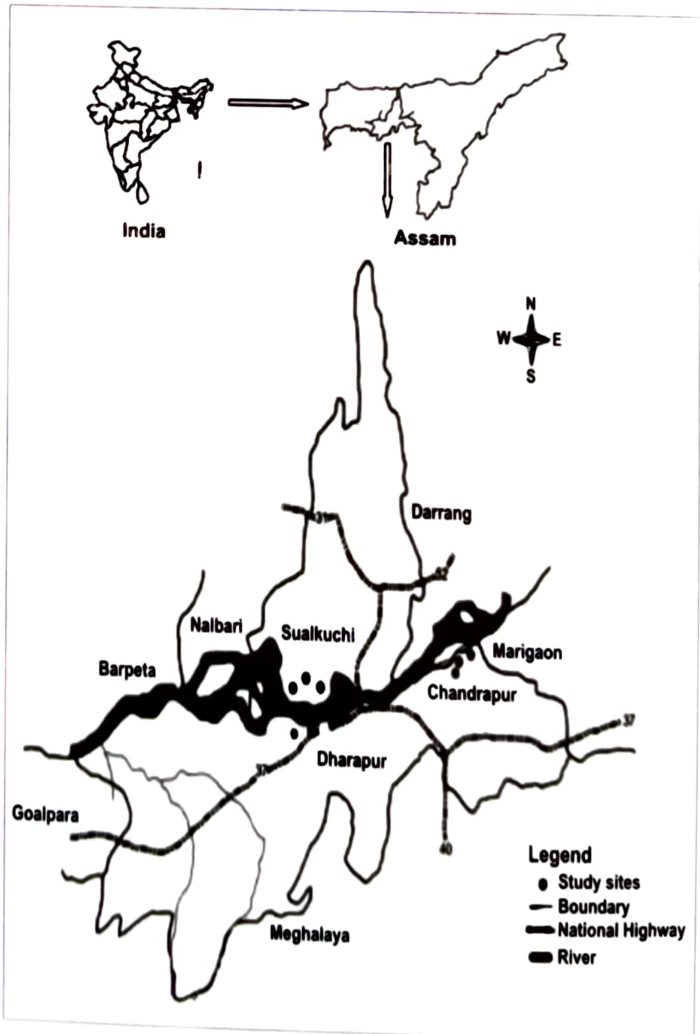
The agronomic potential of cyanobacteria, their distribution and their role in maintaining soil fertility have been extensively studied throughout the world (Watanabe 1959, Chuleuchanon et al. 2003, Begum et al. 2008). Although similar studies were undertaken by various workers in different parts of India (Anand 1998, Singh et al. 2002, Choudhary et al. 2010, Prasana & Nayak 2007, Muthukumar 2007), a little study has been carried out on blue green algae (BGA) in crop fields of Brahmaputra floodplain in general (Ahmed 2000) and Kamrup in particular. Almost all studies are confined to enumeration of the BGA and studies on distributional pattern of those microbes are lacking.

The present endeavour, therefore, was aimed to study the heterocystous nitrogen fixing cyanobacterial diversity with their distributional pattern in different rice fields of Kamrup – an area which had been exploited for rice growing since historical times.

MATERIAL AND METHOD

Study area: The study was conducted in Kamrup (a conglomeration of two administrative districts of Assam) which is located between 25°46' and 26°49' N latitudes and 90°48' and 91°50' E longitudes covering 4345 km^2 area. It is in the confluence of Himalaya and Indo-Burma hotspots. The area is bounded by foothills of Bhutan in the north, Meghalaya in the south, Nagaon and Darrang districts in the east and Goalpara and Nalbari districts of Assam in the west (Text-figure 1). The climate is sub-tropical with semi-arid summer and cold winter. Average humidity is 75% and the maximum and minimum temperatures range from 37° to 39°C and from 6° to 7°C respectively. The annual average rainfall varies between 1500 and 2600 mm and the area experiences maximum rainfall during June to July.

Sampling Method: A total of nine rice fields were selected for sample collection. Sites 1-3 were chosen on the south bank of Brahmaputra from south-west Kamrup. Sites 4-6 were located in the north on the north bank of the river and the sites 7-9 were selected from south-east Kamrup. Soil samples were collected from June 2010 to May 2011 from the depth of 5-15 cm. Each rice field was the composite of five sub-samples and collected soil samples were kept in polythene bags for further processing. Dried and homogenized soil samples were then inoculated in sterilized nitrogen free BG_{11} medium in pre-sterilized flasks under optimal growth condition for 20-25 days at 30° ±2° C temperature in 2.3 K lux light intensity. Culture samples were studied under the microscope to get the morphological characteristics to identify the cyanobacterial species following the standard literature (Desikachary 1959, Tiwari 1972).



Text-figure 1. Study sites in Kamrup region of Assam from where cyanobacteria were collected.

RESULTS AND DISCUSSION

Altogether, 49 heterocystous nitrogen fixing cyanobacteria (Table 1) belonging to 12 genera and 6 families were recorded from nine rice fields of entire Kamrup region. These are: Nostocaceae: (*Anabaena, Anabaenopsis, Aulosira, Cylindros-permum, Nostoc*), Rivulariaceae (*Calothrix, Rivularia*), Scytonemataceae: (*Scytonema, Tolypothrix*),

Table 1. Occurrences of heterocystous Nitrogen fixing cyanobacteria in different rice fields of Kamrup, Assam

Species	Study sites								
	1	2	3	4	5	6	7	8	9
Anabaena ambigua	-	-	-	+	+	+	-	-	-
Anabaena circinalis v. *crassa*	+	+	+	+	+	-	-	+	+
Anabaena constricta	-	+	+	+	+	+	-	-	-
Anabaena doliolum	-	+	-	+	-	+	-	-	-
Anabaena fertillisima	-	-	-	-	+	+	-	-	-
Anabaena flos-aqua	+	+	-	+	-	-	-	-	-
Anabaena iyengarii v. *tenuis*	-	-	-	-	-	-	+	+	+
Anabaena oryzae	-	-	-	-	+	+	-	-	-
Anabaena oscillarioides	-	-	-	-	+	+	+	-	-
Anabaena smithii	-	-	-	+	-	+	-	-	-
Anabaena sphaerica v. *tenuis*	-	-	-	-	-	-	-	+	+
Anabaena spiroides v. *crassa*	-	+	-	-	+	+	-	+	+
Anabaena torulosa	-	+	+	-	-	+	+	-	-
Anabaena variabilis	+	+	-	-	+	+	-	-	+
Anabaenopsis tanganyikae	-	-	-	-	-	-	-	+	-
Aulosira aenigmatica	-	-	-	+	+	-	+	-	+
Aulosira fritschii	-	+	-	-	-	-	+	-	-
Aulosira implexa v. *crassa*	+	-	-	+	+	+	-	+	-
Aulosira pseudoramosa	+	+	-	-	-	-	-	-	-
Calothrix contarenii	+	-	-	-	-	-	-	+	-
Calothrix marchica	-	-	+	-	+	-	-	+	+
Calothrix membranacea	-	-	-	-	-	+	+	-	-
Calothrix ghosei	-	-	-	+	+	+	-	-	-
Calothrix javanica	+	+	+	-	-	+	-	-	-
Cylindrospermum majus	-	-	-	-	-	-	-	-	+
Cylindrospermum musicola	+	+	-	+	+	+	-	-	-
Hapalosiphon delicatulus	+	+	-	-	-	-	-	-	-
Hapalosiphon fontinalis	+	+	-	-	-	-	-	-	-
Hapalosiphon welwitschii	+	-	+	-	-	+	-	-	-
Mastigocladopsis jogensis	-	-	-	+	-	+	-	+	+
Mastigocladus laminosus	-	-	-	+	-	+	-	-	+
Nostoc calcicola	+	+	-	-	-	+	-	-	-
Nostoc carneum	-	+	+	+	-	-	+	-	-
Nostoc commune	-	-	+	+	-	-	-	-	-
Nostoc ellipsosporum	+	+	+	+	+	-	+	-	+
Nostoc hatei	+	-	-	-	+	+	-	+	+
Nostoc linckia	+	-	+	-	+	-	+	+	+
Nostoc maculiforme	+	+	-	-	-	-	-	-	+
Nostoc muscorum	-	-	+	-	-	+	-	+	-
Nostoc peludosum	-	+	+	-	-	-	+	+	+
Nostoc pisinale	+	+	+	-	+	-	-	-	+
Nostoc punctiforme	-	+	-	-	-	-	+	-	-
Nostoc spongiaeforme v. *varians*	+	-	+	+	+	-	+	-	+
Rivularia hansgirgi	-	+	-	+	+	-	+	-	-
Scytonema hofmanni	-	+	-	-	-	+	-	+	-
Scytonema simplex	+	-	-	-	-	+	-	+	+
Tolypothrix byssoidea	-	+	-	+	+	-	-	-	-
Tolypothrix tenuis	-	+	+	-	-	+	+	-	-

Stignemataceae (*Hapalosiphon*), Mastigocladaceae (*Mastigocladus*) and Mastigocladopsidaceae: (*Mastigocladopsis*).

The study site nos. six and two showed higher species richness (24 each) out of all the nine studied plots which was followed by study site five (20) and one (19) respectively (Table 1). Of the algal families, Nostocaceae was the dominant with 34 species (*Anabaena* 15 species, *Nostoc* 12 species, *Aulosira* 4 species, *Cylindrospermum* 2 species and *Anabaenopsis* 1 species) followed by Rivulariaceae with 6 species (*Calohrix* 5 species, *Rivularia* 1 species), Scytonemataceae with 4 species (*Scytonema* 2 species, *Tolypothrix* 2 species). The family Stigonemataceae was represented by 3 species belonging to genus *Hapalosiphon*. Mastigocladaceae and Mastigocladopsidaceae were represented by 1 species each belonging to genus *Mastigocladus* and *Mastigocladopsis* (Table 1).

Among the recorded cyanobacterial genera, *Anabaena circinalis* v. *crassa* and *Nostoc spongiaeforme* v. *varians* were the most frequently occurring species which were followed by *Nostoc ellipsosporum* and *Nostoc linckia* (Table 1).The other species under the genus *Anabaena* which occur occasionally were *A. constricta, A. spiroides, A. torulosa, A. variabilis* and those of genus *Nostoc* were *N. carneum, N. hatei, N. peludosum, N. picinale*. The commonly occurring species of the other genera were as follows: *Aulosira: A. aenigmatica, A. implexa*; *Calothrix: C. marchica, C. ghosei; Cylindrospermum: C. musicola; Hapalosiphon: H. welwitschii; Mastigocladopsis: M. jogensis; Mastigocladus: M. laminosus; Rivularia: R. hansgirgii; Scytonema: S. simplex; Tolypothrix: T. tenius.*

Assam is known to have a conducive agro ecological condition for the growth of the BGA (Deka & Bordoloi 1991, Ahmed 2000), still systematic and quantitative studies were almost lacking. Earlier, Deka and Bordoloi (1991) reported only 11 heterocystous nitrogen fixing cyanobacteria from a rice field of Kamrup district belonging to genera *Anabaena, Cylindrospermum, Nostoc, Scytonema, Tolypothrix, Hapalosiphon* and *Stigonema*. Das et al. (2003) reported only 7 species from Deepor Beel, a ramsar site. The present attempt outnumbered the previous reports with 49 species of nitrogen fixing cyanobacteria. Similarity indices in respect to cyanobacteria inhabiting the nine different rice fields are presented in Table 2. Similarity indices revealed that not even in a single case percentage of similarity were above 80%. The result highlighted not only the differences in cyanobacterial composition in all nine rice grown areas but also indicates heterogeneous nature of the fields. Hence, it needs separate field specific management plans to improve the soil condition and biota. The study revealed that *Anabaena* and *Nostoc*, that belong to the family Nostocaceae, are the two potent nitrogen fixing genera of all the studied rice fields and are also responsible for nitrogen budget therein.

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Table 2. Indices of similarity between the studied rice fields

Study sites	1	2	3	4	5	6	7	8	9
1	1.0	0.56	0.41	0.44	0.46	0.37	0.18	0.29	0.47
2		1.0	0.46	0.56	0.41	0.42	0.42	0.25	0.38
3			1.0	0.52	0.40	0.41	0.48	0.33	0.42
4				1.0	0.78	0.56	0.45	0.26	0.46
5					1.0	0.50	0.35	0.40	0.47
6						1.0	0.21	0.40	0.29
7							1.0	0.20	0.38
8								1.0	0.30
9									1.0

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