Heterocystous blue green algae in paddy fields of Central Plain Zone, Uttar Pradesh, India

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ABSTRACT

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The present paper deals with the distribution of cyanobacterial strains in paddy fields of seven districts of Central Plain Zone, Uttar Pradesh. Ninety two species of heterocystous blue green algae, belonging to 12 genera, have been identified. The following genera have been recorded (number of species in each genus is given in parentheses): *Nostoc* (25), *Anabaena* (19), *Calothrix* (12), *Scytonema* (11), *Cylindrospermum* (6), *Aulosira* (4), *Microchaete* (4), *Hapalosiphon* (4), *Tolypothrix* (3), *Gloeotrichia* (2), *Nodularia* (1) and *Rivularia* (1).

Key-words: Blue green algae, distribution, paddy fields, Central Plain Zone, Uttar Pradesh, India.

INTRODUCTION

Paddy is one of the most extensively grown food crops of India. It occupies an area of about 43 million hectares which is about 37% of the area under total cereal cultivation. Thirty nine percent of the nitrogenous fertilizers produced in India are consumed in its cultivation. Uttar Pradesh has a leading position in the country for paddy production. However, its average yield is only 21 quintals per hectare, which is comparatively lower than that of the other paddy producing states, viz. Punjab, Haryana, Tamil Nadu and Karnataka. This is primarily because about 80% of the farmers of Uttar Pradesh, involved in the paddy cultivation, are with small and marginal land holdings and find it difficult to afford the requisite dose of chemical fertilizers. The production of chemical nitrogen fertilizers is a high budgeted process based on fossil fuels and consequently the cost is ever increasing making farmers hard pressed for this input. Introduction of high yielding varieties has increased production of paddy significantly. However, to exploit full genetic potential of these high yielding varieties application of recommended doses of chemical fertilizer is necessary. The widening gap between the demand and supply and ever increasing prices of fertilizers have pushed them beyond the reach of many of the small and marginal farmers. Therefore, search for cheap and renewable resource, as an alternative source of nitrogen for the crop, becomes most significant.

The available data on nitrogen use efficiency indicates that 1/3 to 1/2 of the applied urea, nitrogen is lost contributing to health and environmental hazards (Prasad 1998). The overall fertilizer utilizing efficiency of the food crop has come down from 17.1 in 1970-71 to 8.1 during 1988-89 (Goyal 1996). This scenario has arrived due to heavy and regular use of chemical nitrogen without considering attention to the carbon content of the soil.

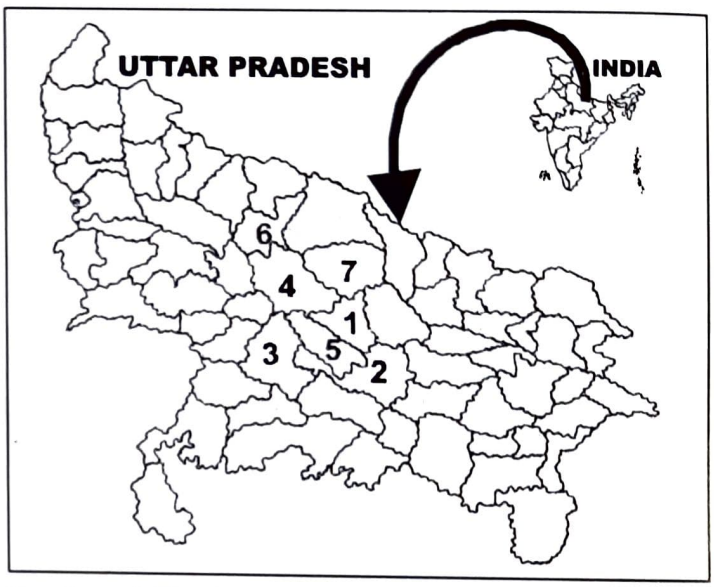
The past few decades have witnessed remarkable advancements in harnessing some of the potentially useful micro-organisms to buildup fertility level of the soil and to increase the crop yield. Many of the blue green algae are agriculturally important, particularly in tropical paddy field soils. This is because of their capacity to fix atmospheric nitrogen and synthesize organic substances. There are series of reports available

on the blue green algal flora of Indian paddy fields (Laloraya & Mitra 1973, Tiwari 1972, Sinha & Mukherjee 1975, Prasad & Mehrotra 1978, 1980, Kolte & Goyal 1985, Mahajan & Patel 1983, Mehrotra 1979, Goyal et al. 1984, Kolte & Goyal 1985, Prasana & Nayak 2007).

More than 125 strains of free living blue green algae have been reported to be capable of fixing nitrogen (Stewart et al. 1979). These nitrogen fixers are considered to be important sources of fixed nitrogen in waterlogged soil and play a significant role in enriching nitrogen in the soil. Since the pioneering contributions of De (1939) and Singh (1942), extensive work on qualitative and quantitative distribution of nitrogen fixing blue green algae has been carried out from various regions of the globe. Studies on periodicity of blue green algal species, in selected paddy fields of Uttar Pradesh and Bihar, have reported abundant growth of species of *Nostoc, Anabaena, Aulosira* and *Cylindrospermum.* However, detailed studies on the subject are rare. During the present investigation, distribution of nitrogen fixing blue green algal strains were studied in order to provide blue green algae map of the region for specific use of atmospheric nitrogen fixing blue green algae in paddy cultivation which could add up to 30 kg per hectare per season. There is ample scope for the use of cyanobacteria as cheap and safe source of nitrogen for the soil. For replacing chemical fertilizer with biological fertilizer in the State, some basic information about nitrogen fixing cyanobacteria, in terms of their occurrence, succession, behavior and fixing capacity, etc. is provided.

MATERIAL AND METHOD

Algal samples were collected directly from waterlogged paddy fields from seven districts, viz. Lucknow, Raebareli, Kanpur, Unnao, Shahjahanpur, Sitapur and Hardoi, in Central Plain Zone of Uttar Pradesh during paddy seasons, 2007-2009 (Text-figure 1). The algae, growing under natural conditions, were scraped and picked up by sterilized spatula from each site and kept in clean, corks fitted and properly labeled glass or plastic bottles. Samples were studied under microscope and details of heterocystous forms were recorded and incorporated in the present study. Identification of the species were based on the morphological characteristics and Camera Lucida sketches were prepared and matched with original description and keys of the species given by Prescott (1951), Tiffany and Britton (1952) and Desikachary (1959).



Text-figure 1. Showing location of districts in Central Plain Zone of Uttar Pradesh, from where heterocystous blue green algal strains were collected. 1. Lucknow, 2. Raebareli, 3. Kanpur, 4. Hardoi, 5. Unnao, 6. Shahjahanpur, 7. Sitapur.

OBSERVATION AND DISCUSSION

The Central Plain Zone covers Lucknow, Kanpur, Raebareli, Unnao, Shahjahanpur, Sitapur and Hardoi districts of Uttar Pradesh. This plain zone is semi-arid with annual temperatures ranging from 6°C to 42.3°C and rainfall from 780 mm to 825 mm. Soil is well drained, alluvial, and loamy to sandy loam and is originated by the Ganga River and its tributaries (Yadav et al. 2001).

Ninety two heterocystous blue green algae, belonging to 13 genera and 5 families, have been observed from paddy fields of 7 districts of Central Plain Zone of Uttar Pradesh. These are: Nostocaceae (*Cylindrospermum, Nostoc, Anabaena, Aulosira* and *Nodularia*), Scytonemataceae (*Scytonema* and *Tolypothrix*), Microchaetaceae (*Microchaete*), Rivulariaceae (*Calothrix, Gloeotrichia* and *Rivularia*) and Stigonemataceae (*Hapalosiphon*). Family Nostocaceae is represented by 55 species

(*Cylindrospermum*: 6 spp., *Nostoc*: 25 spp., *Anabaena* :19 spp., *Aulosira*: 4 spp. and *Nodularia*: 1 species), family Scytonemataceae by 14 species (*Scytonema*: 11 spp. and *Tolypothrix*: 1 species), family Microchaetaceae by 4 species belonging to genus *Microchaete,* family Rivulariaceae by 15 species (*Calothrix*: 12 spp., *Gloeotrichia*: 2 spp. and *Rivularia*: 1 species) and family Stigonemataceae by 4 species belonging to genus *Hapalosiphon* (Table 1).

Table 1. Distribution of heterocystous blue green algae in Central Plain Zone of Uttar Pradesh.

Species	District wise distribution in Central Plain Zone						
	1	2	3	4	5	6	7
Anabaena ambigua	+	-	+	-	+	+	-
Anabaena catenula	+	-	-	-	-	-	-
Anabaena doliolum	+	+	-	+	-	-	-
Anabaena fertilissima	+	+	-	-	+	+	-
Anabaena inaequalis	+	-	-	-	+	-	-
Anabaena iyengarii	+	-	+	+	+	-	-
Anabaena iyengarii var. *tenuis*	+	+	-	-	-	-	-
Anabaena khannae	+	-	-	-	-	-	-
Anabaena naviculoides	+	-	-	-	-	+	+
Anabaena orientalis	+	+	-	-	-	+	-
Anabaena orietalis var. *ellipsospora*	+	-	-	-	-	-	-
Anabaena oryzae	+	-	+	+	+	+	+
Anabaena oscillarioides	+	+	+	-	-	-	+
Anabaena sphaerica	-	-	+	+	+	+	-
Anabaena spiroides	+	+	-	-	-	-	-
Anabaena vaginicola	-	-	-	-	+	-	-
Anabaena variabilis	+	-	+	+	+	-	-
Anabaena variabilis var. *ellipsospora*	+	+	-	-	+	+	-
Anabaena volzii	+	-	-	-	-	-	-
Aulosira fertilissima	+	+	+	-	+	+	-
Aulosira fertilissima var. *tenuis*	-	+	+	+	-	-	-
Aulosira prolifica	+	-	-	+	-	-	-
Aulosira pseudoramosa	-	-	-	+	+	+	-
Calothrix anomala	+	-	+	-	-	-	-
Calothrix braunii	+	-	-	+	-	-	+
Calothrix brevissima	+	+	-	-	+	+	+
Calothrix castellii	+	-	-	-	-	+	-
Calothrix clavatoides	+	-	-	+	+	-	-
Calothrix fusca	-	+	-	+	-	-	-
Calothrix javanica	+	-	-	+	-	-	-
Calothrix lucknowense	+	-	-	-	-	-	-
Calothrix marchica	+	-	-	-	+	-	+
Calothrix marchica var. *intermedia*	-	+	-	-	+	-	-
Calothrix membranacea	+	-	+	-	-	+	-
Calothrix parietina	+	-	-	-	-	+	-
Cylindrospermum majus	+	+	-	+	-	-	-
Cylindrospermum gorakhpurense	+	-	-	-	-	-	-
Cylindrospermum muscicola var. *longispora*	+	-	-	-	-	-	+
Cylindrospermum muscicola var. *vaginata*	-	-	-	-	+	+	-
Cylindrospermum sphaerica	-	+	-	-	+	-	+
Cylindrospermum stagnale	+	-	+	-	-	-	-
Gloeotrichia ghosei	+	-	+	-	+	-	+
Gloeotrichia natans	+	+	-	+	-	-	-
Hapalosiphon delicatulus	+	-	-	-	+	-	+
Hapalosiphon hibernicus	+	-	-	-	-	+	-

Hapalosiphon intricatus	+	+	-	-	-	-	+
Hapalosiphon welwitschii	+	-	+	+	-	-	-
Microchaete tenera	+	-	-	-	+	-	-
Microchaete tenera var. *tenuis*	+	-	+	-	-	-	+
Microchaete calothrichoides	+	+	-	-	-	-	-
Microchaete loktakensis	+	-	-	+	-	+	-
Nodularia spumigena	-	-	+	-	-	+	-
Nostoc amplicimum	+	-	-	-	-	-	-
Nostoc aureum	+	-	-	-	-	-	-
Nostoc austinii	+	-	-	-	-	-	-
Nostoc calcicola	+	-	+	+	-	-	+
Nostoc calcicola f. *variabilis*	+	+	-	-	-	-	-
Nostoc carneum	+	-	-	-	+	-	-
Nostoc citrisporum	+	-	-	-	+	-	-
Nostoc coeruleum	+	-	-	-	-	-	-
Nostoc comminutum	+	-	-	-	-	-	-
Nostoc commune	+	+	+	-	-	+	-
Nostoc depresum	+	-	-	+	-	-	-
Nostoc ellipsosporum	+	-	+	-	-	-	+
Nostoc ellipsoporum var. *violacea*	+	+	-	-	+	-	+
Nostoc glomaratum	+	-	-	-	-	-	-
Nostoc hatei	+	-	-	+	-	-	-
Nostoc humifusum	+	-	+	-	-	-	-
Nostoc linckia	+	+	-	-	-	-	+
Nostoc linckia var. *arvense*	+	-	-	-	-	-	-
Nostoc microscopicum	+	-	-	+	-	-	-
Nostoc minutum	+	-	+	-	-	-	-
Nostoc paludosum	+	-	-	-	+	+	-
Nostoc paludosum var. *majus*	+	+	-	-	-	-	-
Nostoc rivulare	+	-	-	-	+	-	-
Nostoc spongiaeforme var. *tenuis*	+	-	-	-	+	-	-
Nostoc wartisporum	+	-	-	-	-	-	-
Rivularia nitida	+	-	-	-	+	-	-
Scytonema bewsii	+	-	+	-	-	-	+
Scytonema bohneri	+	-	-	-	+	-	-
Scytonema cincinnatum	+	+	-	-	-	+	-
Scytonema coactile	-	+	-	+	+	-	-
Scytonema hofmanni	+	-	-	-	+	-	-
Scytonema javanicum	+	-	+	-	-	+	-
Scytonema mirabile	+	-	-	-	+	-	-
Scytonema ocellatum	+	-	-	-	-	-	+
Scytonema simplex	+	-	+	-	-	-	-
Scytonema tolypothrichoides	+	+	-	+	-	+	-
Scytonema varium	+	-	-	-	-	-	-
Tolypothrix robusta	+	-	-	-	+	-	-
Tolypothrix distorta	+	-	-	-	-	+	-
Tolypothrix fragilis	-	+	+	-	-	-	-

1. Lucknow, 2. Raebareli, 3. Kanpur, 4. Hardoi, 5. Unnao, 6. Shahjahanpur, 7. Sitapur; + = Present, - = Absent.

The maximum number of species (81) was recorded from Lucknow District whereas the minimum number of species (18) was recorded from Sitapur District. 32, 26, 24, 23 and 22 species were recorded from Unnao, Raebareli, Kanpur, Shahjahanpur and Hardoi districts respectively.

The genus *Nostoc* shows maximum representation. The commonly occurring species of this genus are *N. calcicola, N. commune, N. ellipsosporum, N. ellipsosporum* var. *violacea, N. linckia* and *N. paludosum. Nostoc* is followed by *Anabaena* (20 species). The commonly occurring species of *Anabaena* are *A. ambigua, A. doliolum, A. fertilissima, A. iyengarii, A. naviculoides, A. orientalis, A. oryzae, A. oscillarioides, A. sphaerica, A. variabilis* and *A. variabilis* var. *ellipsospora.* The commonly occurring species of other genera are as follows: *Cylindrospermum*: *C. majus* and *C. sphaerica; Scytonema*: *S. bohneri, S. cincinnatum, S. coactile, S. javanicum* and *S. tolypothrichoides; Aulosira*: *A. fertilissima, A fertilissima* var. *tenuis* and *A pseudoramosa; Tolypothrix*: *T. fragilis, T. robusta* and *T. distorta*; *Microchaete*: *M. tenera* and *M. loktakensis; Calothrix*: *C. braunii, C. brevissima, C. clavatoides* and *C. membranacea; Gloeotrichia*: *G. ghosei* and *G. natans*; *Hapalosiphon*: *H. delicatulus, H. intricatus* and *H. welwitschii. Nodularia spumigena* and *Rivularia nitida* were occasionally found. It therefore appears that Nostocaceae is the most important family of blue green algae in paddy field ecosystem and contributes significantly to nitrogen economy of paddy fields in Central Plain Zone, Uttar Pradesh.

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