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Cyanobacteria in rice soils

Z.U.M. Khan, Z.N. Tahmida Begum,* R. Mandal and M.Z. Hossain

Cyanobacteria were recovered from each of 38 soil samples collected from local rice fields. Of the 84 species belonging to 31 genera that were isolated, 42 were heterocystous diazotrophic species belonging to 14 genera and the remaining were non-heterocystous. *Fischerella, Nostoc* and *Calothrix* were widespread.

Key words: Cyanobacteria, diazotrophs, rice field, soil.

The proper fertility and productivity of a rice field has to be maintained if the full genetic potential of the crop is to be exploited. The increasing cost of chemical nitrogen fertilizers has meant that alternative biological sources of nitrogen for optimum crop production are rapidly gaining in importance (Roger & Kulasooriya 1980; Venkataraman 1981). In rice field ecosystems, several N_2-fixing cyanobacterial species offer the most promising biological potential and not only contribute but also benefit the crop in many other ways. Very little information exists on the distribution and edaphic types of the cyanobacteria in the rice fields of Bangladesh (Begum 1983; Khan & Venkataraman 1991). Therefore, to screen for and isolate the most promising strains of N_2-fixing cyanobacteria, 38 rice soils of Dhaka Division, Bangladesh were investigated.

Materials and Methods

Samples of surface soil (0 to 5 cm) were collected from the rice fields of 11 districts of Dhaka Division. Each was a composite sample of five sub-samples. Cultures of cyanobacteria were developed in Fogg's nitrogen-free liquid medium (Fogg 1949) in 250-ml conical flasks under continuous light using 5 g of fresh soil from each soil sample for each of five replicates. Algal forms were examined microscopically from each flask and identified with the help of standard texts (Desikachary 1959; Islam & Begum 1981). For each sample, 50 foci in 10 slides were studied. Standard methods were used for the determination of pH, organic carbon, available phosphorus (Williams & Stewart 1941) and total N in the soils (Table 1).

Z.U.M. Khan is with the Department of Botany, Jahangirnagar University, Savar, Dhaka, Bangladesh. Z.N. Tahmida Begum and M.Z. Hossain are with the Department of Botany and R. Mandal is with the Department of Soil Science, both at the University of Dhaka, Dhaka-1000, Bangladesh; fax: (880-2) 865583. *Corresponding author.

Results and Discussion

Table 2 reveals that each of the 38 soil samples harboured cyanobacteria and that the distribution of them varied markedly from soil to soil. This variation might be due to variation in soil properties (Table 1). Moreover, it is evident that 50% of the 84 species recorded were heterocystous, diazotrophic and belonged to one of 14 genera. The remaining 50% were non-heterocystous species belonging to one of 17 genera. In each district, about 50% of the recorded forms were heterocystous.

Except in two soils (samples 18 and 27), heterocystous forms of cyanobacteria comprised 3.0 to 11% of the total forms recorded. The highest proportion was observed in the district of Tangail (samples 12 and 13). In an all-India survey, Venkataraman (1975) reported that about 33% of the 2213 soil samples harboured N_2-fixing forms, indicating that N_2-fixing cyanobacteria do not invariably occur in every tropical rice soil. It was therefore not surprising to find only *Aulosira implexa* in Gopalpur (sample 6) and only *Cylindrospermum* in Mirzapur (sample 13). The reasons for the heterogenous and sometimes limited distribution of diazotrophic cyanobacteria are still not well known, as no systematic analysis has been correlated with environmental factors (Lowendrof 1980). Among the N_2-fixing forms, species of *Fischerella, Nostoc* and *Calothrix* were found to be widespread, occurring in about 53%, 47% and 26% of the soil samples, respectively (Table 2). Goyal (1982) also reported the wide distribution of *Nostoc* and *Calothrix*, and also of *Aulosira* and *Anabaena* in rice soils of India.

Hapalosiphon welwitschii was common in soils with pH values ranging from 6.9 to 7.8 (Tables 1 and 2). On the other hand, *Fischerella, Calothrix, Scytonema* and *Tolypothrix* occurred in the moderately acid soil of Kishorganj (Tables 1 and 2). This is in good agreement with the findings of Khan & Venkataraman (1991).

Table 1. Soil properties and number of cyanobacterial genera in rice-field soil samples.

Sample	District	pH	Soil property			No. of cyanobacterial genera		
			Organic C %	Total N %	Available P (mg/g)	Total	Heterocystous	Nonheterocystous
1 to 2	Dhaka	7.1	1.41	0.18	13.7	9	4	5
3	Narayanganj	7.0	2.44	0.22	21.5	3	2	1
4	Narashingdi	7.1	0.85	0.12	11.4	3	2	1
5 to 13	Tangail	7.1	0.68	0.18	9.9	24	13	11
14 to 17	Faridpur	7.5	0.50	0.16	11.0	11	5	6
18 to 21	Rajbari	7.7	0.28	0.11	11.7	13	6	7
22 to 23	Gopalganj	7.6	0.32	0.13	12.3	6	5	1
24 to 27	Madaripur	7.4	0.45	0.14	12.3	12	5	7
28 to 33	Sariatpur	7.4	0.46	0.15	13.5	12	5	7
34 to 37	Mymensingh	7.0	0.38	0.11	9.8	9	7	2
38	Kishorganj	5.3	0.26	0.07	14.2	4	4	0

Table 2. Distribution of cyanobacterial species in 38 rice-field soil samples from Dhaka Division

Species	Soil samples positive for species*	Species	Soil samples positive for species*
Microcystis aeruginosa	12,13	*Nos. commune*	24
Chroococcus giganteus	18	*Nos. hatei*	12
C. macrococcus	2	*Nostoc* sp.	2, 35, 37
C. pallidus	12, 18	*Anabaena oryzae*	12, 13
Chroococcus sp.	5,10	*An. orientalis*	7, 28
Gloeocapsa decorticans	9	*An. iyengarii*	26
G. pleurocapsoides	18	*An. laxa*	4
G. calcarea	17,36	*An. fertilissima*	7, 12
G. punctata	12, 18, 29, 30	*Microchaete tenera*	2, 12, 13, 24
Gloeothece sp.	5	*Pseudoanabaena* sp.	4, 26, 32, 24
Aphanocapsa pulchra	18	*Nodularia* sp.	15
Aphanoc biformis	7, 12	*Raphidiopsis indica*	26
Aphanocapsa sp.	7	*Aulosira bombayensis*	7
Aphanothece sp.	6, 7, 18, 35	*Au. aenigmatica*	6, 15
Synechocystis pevalekii	14, 17, 19, 21	*Au. implexa*	6
Synechocystis aquatilis	15	*Au. fertilissima*	34
Synechococcus aeruginosus	18	*Aulosira* sp.	7, 34
Myxosarcina sp.	12	*Plectonema* sp.	8, 9, 11, 12, 13, 14, 19, 20, 22, 25, 30, 31, 33, 35, 36, 37
Oscillatoria peromata	24, 27, 29	*Scytonema hofmanii*	38
O. limosa	14, 19	*S. burmanicum*	20
O. animalis	11	*S. mirabile*	13, 27
O. subbrevis	5, 18, 25, 30	*S. schmidtii*	28
O. curviceps	14, 15, 31, 33	*Scytonema* sp.	3, 13, 34, 37
O. proboscidea	33	*Tolypothrix byssoidea*	31, 32, 38
O. chlorina	19	*T. fragilis*	32
O. terebriformis	14, 27	*Tolypothrix* sp.	13, 20, 31
O. rubescens	27	*Calothrix crustacea*	13
O. acuminata	11, 25, 27, 32	*Ca. javanica*	12
O. simplicissima	10, 18	*Ca. wembaerensis*	12
O. martini	2, 18, 30	*Ca. elenkinii*	12, 13, 24
Phormidium ambiguum	2, 15, 18, 23, 27, 29, 31	*Ca. parietina*	12, 25
Phormidium sp.	3, 9, 10, 13, 14, 16, 19, 30, 33, 36	*Ca. marchica*	2, 12, 13, 25, 31, 33, 37, 38
Lyngbya truncicola	10, 14, 15, 16, 25, 31	*Calothrix* sp.	2, 25, 35, 38
L. ceylanica	2, 3	*Hapalosiphon welwitschii*	5, 6, 8, 9, 17, 20, 23, 28, 32, 36
L. dendrobia	25, 26, 27	*H. fontinalis*	22
L. martensiana	10	*H. stuhlmannii*	35
L. connecteus	2, 11, 25, 26	*Mastigocoleus testarum*	14, 16, 17, 21, 23
Schizothrix lamyi	24, 25	*Westiellopsis prolifica*	9, 16, 17, 21, 23, 35
Microcoleus sp.	1, 28, 31	*Fischerella ambigua*	1, 5, 6, 7, 19, 22, 25, 26, 29, 30, 33, 35
Cylindrospermum muscicola	13, 36	*Fischerella* sp.	8, 9, 10, 20, 23, 28, 32, 38
Nostoc linckia	4, 5, 6, 11, 19, 22, 24, 26, 36	*Stigonema* sp.	8, 20
Nos. piscinale	1, 10, 11		
Nos. carneum	3, 6, 7, 22		

* See Table 1 for sample origin.

Single correlation analysis revealed that an increase in available P could significantly affect the genera of heterocystous N_2-fixing cyanobacteria in soil. However, the significant coefficient seen on multiple correlation analysis indicates that the combined contribution of pH, organic C, total N and available P may affect the type of cyanobacteria more than any individual effect.

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