

Studies on the distribution of blue-green algae in paddy fields of Uttaranchal state

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The present study deals with the distribution of blue-green algae in paddy fields of different localities of the Haridwar and Dehradun districts. A total of 27 heterocystous species of blue-green algae, belonging to the genera *Nostoc* (5), *Anabaena* (8), *Cylindrospermum* (3), *Scytonema* (5), *Calothrix* (2), *Tolypothrix* (1), *Gloeotrichia* (2) and *Microchaete* (1), were recorded during the course of present investigation.

Key-words – Blue-green algae, Rice fields, Uttaranchal.

INTRODUCTION

RICE fields are best thriving ground for the growth of blue-green algae because of the prevailing high temperature, high humidity and water logged condition during the rice-growing season. Importance of blue-green algae in soil fertility and nitrogen economy of tropical soils has been well documented. Many workers have reported blue-green algae from paddy fields of India (Banerji 1935, Gonzalves & Gangla 1949, Mitra 1951, Bongale & Bharati 1980, Laloraya & Mitra 1973a, b, c, Agarkar 1967, Pandey 1965, Patil & Salav 1986, Singh & Bisnoi 1989, Goyal *et al.* 1984, Prasad 1952 1962, Tewari 1976, 1979). From Uttar Pradesh as well, a large number of blue-green algae have been described (Khan 1985, Mitra 1951, Gupta 1966, Bendre & Kumar 1975, Nair 1964, Prasad & Mehrotra 1978, 1980, Khan & Mathur 1974, Shukla 1971, Kumat 1973, Kusumlata 1965, Pandey 1965). However, there is little information about the blue-green algae of Haridwar and Dehradun district - the districts taken up during the present study. Considering the importance of blue green algae in nitrogen economy in rice cultivation, there is an immediate need to study the occurrence and distribution of nitrogen fixing strains with a view to provide region specific blue- green algal biofertilizer to the farmers of the regions.

MATERIAL AND METHOD

Haridwar and Dehradun districts of the Uttaranchal state were selected for the study on distribution of blue-green algae from paddy fields. Haridwar and Dehradun have a sub-humid climate with temperature ranging from 4.03 °C to 38.4 °C and rain fall from 1300 to 1400 mm. The soil is alluvial (loam to clay loam) which has originated from Shivalik range of the Himalayas.

The collection of algae, was made directly from waterlogged rice fields from different localities of two districts during July-September. During this period, the fields are generally in waterlogged condition with abundant growth of algal flora. The algae growing under natural conditions were also scrapped and picked up by sterilized spatula from each spot and were collected in clean plastic bottles by using sterilized forceps. The collected samples were brought to the laboratory and preserved in 4% formalin. The identification of different taxa was done with the help of keys given by Desikachary (1959) and Prescott (1951).

The chosen localities were Dhanauri, Roorkee (Haridwar); Military farm Roorkee (Haridwar); Bongla, Bahaderabad (Haridwar); Jiyapota Missirpur (Haridwar); Sherpur, Bhagwanpur (Haridwar),

Dhadheki, Laksar (Haridwar); Husainpur, Laksar (Hairdwar); Belra, Saliyar, (Hairdwar); Shekhpuri and Thakrani (Dehradun).

RESULT AND DISCUSSION

A total of 27 species of heterocystous blue-green algae were observed and identified. The family Nostocaceae is represented by three genera, i.e. *Anabaena*, *Nostoc* and *Cylindrospermum*. *Anabaena* is represented by eight species, *Nostoc* is represented by five species while *Cylindrospermum* is represented by three species. Family Scytonemataceae is represented by two genera, *Scytonema* with five species and *Tolypothrix* with one species only. Family Rivulariaceae is represented by two genera, *Gloeotrichia* (two species) and *Calothrix* (two species) and Microchaetaceae is represented by single species, *Microchaete uberrima* from two different localities.

1. *Cylindrospermum gorakhpurensense* Singh

Singh R.N., 1936, *Proc. Ind. Acad. Sci.* 9(B): 65. Desikachary, 1959, *Cyanophyta* p. 363, pl. 74, fig. 4.

Trichomes 4.0-5.0 μm broad; cells quadrate or cylindrical 6.0-11.0 μm long, heterocysts 6.0-8.0 μm broad, 130-16.0 μm long. Collected from Bongla and Bahaderabad.

2. *Cylindrospermum majus* Kutz. ex Bornet et Flah

Bornet et Flahault, 1988, Revision des Nostocacees he 'te' rocyste'es, 252; Forti in De Toni, 1907, *Sylloge Algarum*, 5: 474. Geitler, 1932, *Kryptogamenflora*, p. 815. fig. 520b. Prescott, 1951, *Algae of Western Great Lake Areas*, p. 530, pl. 122. Desikachary, 1959, *Cyanophyta* p. 360, 362, pl. 80, fig. 1. Tewari & Pandey, 1976, *Nova Hedwegia*, 27: p. 701, pl. 1, fig. 3.

Trichomes 3.0-4.0 μm broad; 4.0-6.0 μm long; heterocysts oblong, cylindrical, 4.0-5.0 μm broad, 6.0-10.0 μm long; spores present at one end ellipsoidal 10.0-15.0 μm broad, 20.0-30.0 μm long. Collected from Dhanauri, Belra and Saliyar.

3. *Cylindrospermum stagnale* (Kutz.) Born. et Flah

Bornet et Flahault, 1988, Revision des Nostocacees he te rocyste'es, 250; Forti in De Toni, 1907, *Sylloge Algarum*, 5: 472. Fremy, 1929. *Myxod' Afr. E' quqt. Franc* 375, fig. 311. Geitler 1932, *Kryptogamenflora der Mark Brandenburg*, p. 819, fig. 520c. Prescott, 1951, *Algae of Western Great Lake Areas*, p. 531, pl. 122, fig. 17, 18. Desikachary, 1959, *Cyanophyta* p. 363-364, pl. 65, fig. 9. Tewari & Pandey, 1976, *Nova Hedwegia*, 27: p. 704, pl. 2, fig. 3.

Trichomes 3.5-4.0 μm broad; cells nearly quadrate to cylindrical, 3.5-4.0 μm broad, 3.8-5.0 μm long; heterocysts 4.5-5.0 μm broad, 4.0-6.0 μm long; spores 8.0-12.0 μm broad, 15.0-2.0 μm long. Collected from Bongla, Bahaderabad, Dhadheki, Laksar and Thakrani.

4. *Anabaena ambigua* Rao

Rao, 1937, *Proc. Ind. Acad. Sci.* 5(B): figs 1-2. Desikachary, 1959., *Cyanophyta*, p. 400, pl. 76, fig. 2.

Trichomes with cells 4.0-5.0 μm broad, 3.0-4.0 m long, heterocysts interalary, 5.0-6.0 μm in diameter. Collected from Dhnauri, Dhadheki, Laksar and Thakrani.

5. *Anabaena iyengarii* var. *tenuis* Rao

Rao, 1937b. *Proc. Ind. Acad. Sci.* 6(6) : 361, fig. 5 A-C. Desikachary, 1959. *Cyanophyta*, p. 408, pl. 76, fig. 1

Trichomes with cells 3.5-4.5 μm broad, 3.0-5.0 μm long; heterocysts 3.5-4.5 m broad, 5.5-6.5 μm long, spores 7.0-8.0 μm broad, 9.0-10.0 m long. Collected from Military farm Roorkee, Bongla and Bahaderabad.

6. *Anabaena fertilissima* Rao

Rao 1937b. *Proc. Ind. Acad. Sci.* 6(6): 363, fig. 6 A-C. Desikachary, 1959. *Cyanophyta*, p. 398, pl. 74, fig. 1.

Trichomes with cells 5.0-6.0 μm broad, 2.0-4.0 μm long, heterocysts spherical 5.0-8.0 μm in diameter, spores almost spherical 6.0-8.0 μm in diameter. Collected from Dhanauri, Jiyapota and Missirpur.

7. *Anabaena oscillarioides* Bory ex Bornet et Flah

Bornet et Flahault, 1888, Revision des Nostocace'e heterocyste'es, 233. Geitler *Kryptogamenflora*, 886, fig. 567e. Desikachary, 1959. *Cyanophyta*, p.417, pl.71, fig. 7. Prescott 1951, *Algae of the Western Great Lake Areas*, p. 517, Pl 117, fig. 8-10.

Trichome with cells 4.0-5.0 μm broad, as long as broad; heterocysts 6.0-8.0 μm broad, 6.0-10.00 μm long; spores 7.0-10.0 μm long. Collected from Military farm Roorkee. Saliyar, Husainpur and Laksar.

8. *Anabaena oryzae* Fritsch

Fritsch, 1949, *J. Ind. bot. Soc.*, 28: 135, figs. 1-16. Desikachar, 1959. *Cyanophyta*, pl. 72, fig. 3.

Trichomes with cells 3.0-35 μm broad, 3.0-7.0 μm ; heterocysts 3.5-5.0 μm broad, 6.0-8.0 μm long; spores 4.0-6.0 μm broad 7.0-9.0 μm long. Collected from Dhanauri and Husainpur.

9. *Anabaena sphaerica* var. *tenuis* West.

Fremy, 1929. *Myxo. d' Afr. E'quqt. Franc.*, 361. Geitler, 1932, *Kryptogamenflora*, p. 878, fig. 560b. Desikachary T.V., 1959. *Cyanophyta*, p. 393, 395, pl. 71, fig. 10., Tewari & Pandey 1976, *Nova Hedwigia*, 27: 714, pl. 9, fig.2.

Trchomes with cells 4.5-6.0 μm broad, 2.5-4.5: m long; heterocysts 5.0-7.0 μm broad, 5.0-7.0 μm long; spores 10.0-12.0 μm long. Collected from: Sherpur and Bhagwanpur.

10. *Anabaena torulosa* (Carm.) Lagerh. ex Born et Flah

Bronet et Flahault, 1888, Revision des Nostocace'e heterocyste'es, 236. Forti in De Toni, 1907, *Sylloge Algarum*, 5: 455. Geitler 1932, *Kryptogamenflora*, p. 887, fig. 567d. Desikachary, 1959. *Cyanophyta*, p.415, pl. 74, fig. 2. Prescott G.W., 1951, *Algae of Western Great Lake Areas.*, p. 518, pl. 131, fig. 5.

Trichomes with cells 4.2-5.0 μm broad almost as long as or slightly shorter than broad; heterocysts 6.0 μm broad and 6.0-10.0 μm long; spores 7.0-12.0 μm broad upto twice as long as broad. Collected from

Bongla and Bahaderbad.

11. *Anabaena utermohlii* Geitler

In Pascher's Susswasserflora, 443, 1925. Geitler 1932, *Kyptogamenflora*, p.884, Desikachary 1959, *Cyanophyta* p. 415, pl.74, fig.2.

Trichomes with cells 4.0-4.5 μm broad, 4.0-6.5 μm long; heterocyst 4.0-4.5 μm broad, 5.0-6.0 μm long; spores 7.0-9.0 μm broad 19.0-0.22 μm long.

12. *Nostoc linckia* (Roth) Bornet et Flah

Bornet et Flahault, 1888, Revision des Nostocace'e heterocyste'es, 192. Forti in De Toni, 1907, *Sylloge Algarm*, 5: 391. Geitler 1932, *Kyptogamenflora*, p. 838 fig.528b, Desikachary 1959, *Cyanophyta* p. 377.

Trichomes with cells 3.0-4.0 μm borad, 2.0-4.0 long, heterocyst spherical 3.0-4.0 μm in diameter; spores 4.0-7.0 μm broad, 6.0-8.0 μm long Collected from Belra and Dhanauri.

13. *Nostoc comminutum* Kutzing

Forti in De Toni, 1908, *Sylloge Algarum*, 5: 393; Tilden, J. The Myxophyceae of North America, *Bibliotheca Phycol.*, 165, 1910; Prescott G.W., 1951, *Algae of Western Great Lake Areas.*, p. 522, pl. 119, fig. 12.

Trichomes straight or twisted, densely entangled, with cells spherical or compressed, 3.0-4.0 μm in diameter; heterocysts spherical 4.0-5.0 μm in diameter. Collected from Bongla, Bahaderabad and Saliyar.

14. *Nostoc calcicola* Brebisson ex Born. et Flah

Bornet et Flahault, 1888, Revision des Nostocace'e heterocyste'es, 202. Forti in De Toni, 1907, *Sylloge algarum*, 5: 402. Geitler 1932, *Kyptogamenflora*, p.842 fig. 534, Desikachary 1959, *Cyanophyta* p. 384-85, pl. 68, fig.1.

Trichomes with cells 2.5-3.0 μm broad, barrel shaped or oblong, shorter than broad, 1.5-4.0 μm long. Heterocysts globose or subglobose borader than vegetative cells, 2.0-4.0 μm in diameter. Spores spherical or sub-spherical 4.0-6.0 μm in diameter. Collected from Military farm, Roorkee, Dhadheki and Shekhpuri.

15. *Nostoc commune* Voucher ex Born. et Flah.

Bornet et Flahault, 1888, *Revision des Nostocace's heterocyste'es*, 203. Forti in De Toni, 1907, *Sylloge Algarum*, 5: 404. Fremy, 1929. *Myxo.d' Afr.e'quqt. Franc.*, 342 fig. 283. Geitler, 1932, *Kryptogamenflora*, p. 845, fig. 536-37., Prescott G.W., 1951, *Algae of Western Great Lake Areas*, p. 523, pl. 119, fig. 13. Desikachary 1959, *Cyanophyta* p.387, pl. 68, fig.3.

Trichomes with cells 4.5-6.0 μm broad, short spherical. Heterocysts 6.0-7.0 μm in diameter. Collected from Thakrani, Dehradun, Shekhpuri, Sherpur, Bhagwanpur, Jiyapota, Missirpur and Dhanuari.

16. *Nostoc depressum* Wood

Forti in De Toni, 1907, *Sylloge Algarum*, 5:415; Tilden, J., 1910, *The Myxophyceae of North America, Bibliotheca Phycol.*, 177.

Trichomes with cells 3.5-4.0 μm broad, 3.0-4.0 μm in length, barrel shaped. Heterocysts 5.0-6.0 μm in diameter. Collected from Military farm, Roorkee and Husainpur.

17. *Scytonema bohneri* Schmidle

Forti in De Toni, 1907, *Sylloge Algarum*, 5: 501; Fremy, 1929. *Myzod' Afr. E'quqt. Franc.*, 302; Desikachary 1959, *Cyanophyta* p.457, pl. 87, fig.1.

Trichomes with cells 6.0-8.0 μm broad, rectangular, shorter than broad. Heterocysts 6.0-8.0 μm broad, 8.0-10.0 μm long. Collected from Military farm, Roorkee, Belra and Shekhpuri.

18. *Scytonema coactile* Montagne ex Born et Flah

Bornet et Flahault, 1887, *Revision des Nostocace'e heterocyste'es*, 90. Forti in De Toni, 1907, *Sylloge Algarum*, 5: 501. Fremy, 1929. *Myzod' Afr.e'quqt. Franc.*, 300. fig. 258. Geitler, 1932, *Kryptogamenflora*, p. 753, fig. 479, Prescott, 1951, *Algae of Western Great Lake Areas*, p. 534-35, pl. 124, fig. 1-3. Desikachary 1959, *Cyanophyta* p. 455, 457, pl. 90, fig.2.

Filaments 16.0-18.0 μm in width; Trichomes with

cells 12.0-18.0 μm broad, subquadrate or compressed, barrel shaped or longer than broad. Heterocysts 15.0-25.0 μm long, 12.0-17.0 μm broad.

19. *Scytonema hofmannii* Ag. Ex Born et Flah

Bornet et Flahault, 1887, *Revision des Nostocace'e heterocyste'es*, 97. Forti in De Toni, 1907, *Sylloge Algarum*, 5: 513. Fremy, 1929. *Myxod' Afrie.quqt. Franc.*, 313. fig. 266. Geitler, 1932, *Kryptogamenflora* p. 772, fig. 495. Desikachary, 1959, *Cyanophyta* p. 476, pl. 92, fig. 2.

Filaments 6.0-10.0 μm in width, Trichomes with cells 5.0-9.0 μm broad, 2.5-9.0 μm long short cylindrical or barrel shaped; Heterocysts single, 5.0-7.5 μm broad, 7.5-10.0 μm long. Collected from Husainpur, Laksar, Sailyar, Thakrani.

20. *Scytonema mirabile* (Dillw) Born

Forti in De Toni, 1907, *Sylloge Algarum*, 5: 517. Fremy, 1929. *Myxod' Afr.equqt. Franc.*, 319. fig. 269. Geitler, 1932, *Kryptogamenflora*, p. 775, fig. 497, 498. Prescott 1951, *Algae of Western Great Lake Areas*, p. 535, pl. 124, fig. 7-8. Desikachary 1959, *Cyanophyta* p. 483, 485, pl. 81, fig. 3.

Filaments 15.0-17.0 μm broad, torulose; Trichomes with cells 10.0-14.0 μm broad, 5.0-15.0 μm long. Heterocysts 13.0-15.0 μm long and 7.10-12.0 μm broad. Collected from Jiyapota, Missirpur, Belra, Shekhpuri.

21. *Scytonema javanicum* (Kutz) Bornet ex Born et Flah

Bornet et Flahault, 1887, *Reivision des Nostocace'e heterocyste'es*, 95. Forti in De Toni, 1907, *Sylloge Algarum*, 5: 506. Fremy, 1929. *Myxo. D' Afr. E'quqt. Franc.*, 309. fig. 264. Geitler, 1932 *Kryptogamenflora*, p. 765, fig. 490. Desikachary 1959, *Cyanophyta* p. 461, pl. 100, fig. 4.

Filaments 12.0-18.0 μm broad; Trichomes with cells 7.5-12.5 μm broad, 7.0-13.0 μm long, Heterocyst 7.5-12.5 μm broad, 12.5-15.5 μm long. Collected from Dhanauri, Roorkee, Husainpur, and Thakrani.

22. *Calothrix elenkinii* Kossinskaja

Geitler, 1932, *Kryptogamenflora*, p.609, fig. 383 (5-6). Desikachary 1959, *Cyanophyta* p. 531, pl. 114 fig. 5,6,11.

Filaments 100-200 μm long bent at the base; Trichomes with cells 5.0-7.0 μm broad at base, 4.0-6.0 μm broad in the middle, sheath close fitting thin unlamellated. Heterocyst basal, subspherical 4.0-6.0 μm in diameter. Collected from Belra.

23. *Calothrix fusca* (Kutz.) Bronet et Flahault

Forti in De Toni, 1907, *Sylloge Algarum*, 5: 617. Frey, 1929. *Myxod' Afr. E'quqt. Franc.*, 249. fig. 222. Geitler, 1932, *Kryptogamenflora*, p. 610, fig. 384. Prescott G.W., 1951, *Algae of Western Great Lake Areas*, p. 533pl. 132, fig 4-5. Desikachari T.V., 1959, *Cyanophyta* p. 527, pl. 107, fig. 10.

Filaments 10.0-15.0 μm broad at the base, 6.0-10.0 μm broad in middle, sheath broad unlamellated; Trichomes with cells 7.0-9.0 μm broad at the base, 5.0-8.0 μm in middle, not constricted at cross walls. Heterocysts basal, hemispherical, 5.0-6.0 μm long 5.0-8.0 μm broad. Collected from Military farm, Roorkee, Husainpur, and Thakrani.

24. *Tolypothrix nodosa* Bharadwaja

Bharadwaja 1934, *Rev. Algol. (Paris)*, 7:715, fig. 7c; Desikachary 1959, *Cyanophyta* p.494, pl.98, fig. 5.

Filaments densely entangle, 8.0-10.0 μm broad; Trichomes with cylindrical or barrel shaped cells 5.0-8.0 μm broad, 4.0-12.0 μm long, constricted at cross walls; Heterocysts terminal (basal) and intercalary, ellipsoidal, rarely cylindrical, 6.0-8.0 μm broad, 8.0-12.0 μm long. Collected from Dhanauri.

25. *Microchaete uberrima* Carter

Carter N., 1926, *Rec. Bot. Surv. India*, 9: 268 pl. 1 figs. 1-3; Geitler, 1932 *Kryptogamenflora*, p. 669, fig. 430.

Desikachary, 1959, *Cyanophyta* p. 511, pl. 104, fig. 10, 13, 16, 18.

Filaments long, 15.0-18.0 μm broad at base, 5.0-7.0 μm broad at apex; Trichomes with cells 10.0-12.0

μm broad at base; Heterocysts basal and intercalary-basal heterocysts spherical, 8.0-10.0 μm in diameter, intercalary heterocysts 7.0-8.0 μm broad, 10.0-13.0 μm long, rectangular. Collected from Dhanauri and Dhadheki.

26. *Gloetrichia natans* Rabenhorst ex Born et Flah

Bornet et Flahault, 1886, *Revision des Nostocace'es he'te'rocyste'es*, 369; Frey, 1929. *Myxo.d' Afr. Equqt. Franc.*, 276. fig. 246. Geitler, 1932, *Kryptogamenflora*, p. 639, fig. 406, 407. Prescott G.W., 1951, *Algae of Western Great Lake Areas*, p. 559, pl. 124, fig. 7-8. Desikachari, 1959, *Cyanophyta* p. 483, pl. 134, fig. 6,7.

Trichomes attenuated into long hairs, 7.0-9.0 μm broad, with cells subglobose or barrel shaped at the base, as long as broad, may be up to four times as long as broad in distal part; Heterocyst basal, more or less spherical, 6.0-12.0 μm in diameter; spores cylindrical slightly bent, 10.0-18.0 μm broad and 40.-250.0 μm long, with sheath up to about 40.0 μm broad. Collected from Bongla, Bahaderabad, Dhadheki and Thakrani.

27. *Gloetrichia ghosei* Singh

Singh 1939, *Proc. Ind. Acad. Sci. B.*, 9:64, fig. A-C. Desikachary 1959, *Cyanophyta* p. 561, pl. 118, fig. 1-3

Trichomes attenuated into long hairs, barrel shaped, constricted at cross walls, 8.0-10.0 μm broad at base, 4.0-8.0 μm broad in distal parts; Heterocysts basal, spherical, 10.0-12.0 μm in diameter; spores long single, ellipsoidal, 15.0-17.0 μm broad 50.0-55.0 μm long. Collected from Dhanauri, Jiyapota Missirpur and Belra.

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