New records of heterocystous *Cyanophyta* from paddy fields of Iran

گزارش‌های جدیدی از سیانوباکتری‌های دارای هتروسیست در مزارع برنج ایران*

Received: 09.02.2010 / Accepted: 14.08.2010

دریافت: ۱۳۸۸/۱۱/۲۰/ پذیرش: ۱۳۸۹/۵/۲۳

Z. Shariatmadari: Ph.D. student, Faculty of Biosciences, Shahid Beheshti University, G.C., Tehran, Iran

H. Riahi✉: Prof., Faculty of Biosciences, Shahid Beheshti University, G.C., Tehran, Iran
(E-mail: h-riahi@cc.sbu.ac.ir)

Abstract

Four paddy fields in Guilan province in the north of Iran seasonally were sampled from April 2008 to January 2009. Twenty-two morphospecies belonging to three families of the heterocystous blue-green algae were identified. Fourteen species and one variety of these taxa are new record for Iran. Among the families *Nostocaceae* with six genera and 16 species showed the highest species richness.

Keywords: Blue-green algae, identification, morpho-species, Iran

زینب شریعتمداری: دانشجوی دکترای دانشکده علوم زیستی، دانشگاه شهید بهشتی، تهران

حسین ریاحی✉: استاد دانشکده علوم زیستی، دانشگاه شهید بهشتی، تهران
(E-mail: h-riahi@cc.sbu.ac.ir)

چکیده

طی این تحقیق جلبک‌های سبز-آبی چهار شالیزار در استان گیلان، با نمونه‌برداری فصلی از اردیبهشت تا بهمن ۱۳۸۷، مورد مطالعه و شناسایی قرار گرفتند. بیست و دو ریخت‌گونه متعلق به سه تیره از جلبک‌های سبز-آبی دارای هتروسیست شناسایی شدند. از میان تیره‌های شناسایی شده، *Nostocaceae* با شش جنس و ۱۶ گونه بالاترین تنوع گونه‌ای را نشان داد. چهارده گونه و یک واریته از نمونه‌های شناسایی شده برای نخستین بار از ایران گزارش می‌شوند.

واژه‌های کلیدی: جلبک سبز-آبی، شناسایی، ریخت‌گونه، ایران

Introduction

Blue-green algae (BGA) represent an ancient group of photosynthetic prokaryotes, whose ubiquity, metabolic flexibility and adaptive abilities have made them a subject of research worldwide (Prasanna *et al*. 2008). These are cosmopolitan micro-organisms, which play significant roles in diverse ecosystems. Approximately 150 genera representing more than 1,000 species of cyanobacteria have been described (Rippka *et al*. 1979). The Paddy field ecosystem represents a favourable environment for the growth of cyanobacteria fulfilling the requirements of light, water, temperature, humidity and nutrient availability in an optimal manner (Prasanna & Nayak 2007). The favourable conditions provided by the rice fields for nitrogen fixation by these organisms leads to enhanced plant available N in soil and yield improvement of rice (Roger *et al*. 1993, Mandal *et al*. 1998).

Among the beneficial effects of cyanobacteria, apart from supplying nitrogen in rice fields, their influence on the physical, chemical and biological properties of the soil and soil water interface has immense significance (Singh 1950, Oikarinen 1996). Cyanobacteria liberate extracellular substances and modulate pH, temperature and redox activity, besides playing a role in the volatilization of ammonia and methane generation; therefore, they are directly or indirectly implicated in the management and productivity of rice ecosystem (Mandal *et al*. 1998, Prasanna *et al*. 2002).

* بخشی از رساله دکترای نگارنده اول به راهنمایی دکتر حسین ریاحی ارایه شده به دانشگاه شهید بهشتی

The abundance of cyanobacteria in rice fields has already been reported (Fritsch 1907a, b). Studies on algal flora have received little attention in Iran and there are few published surveys of algal flora (Compere 1981). In spite of broad paddy fields in Iran there are few studies on the taxonomy of soil heterocystous cyanobacteria (Nowruzi & Ahmadimoghadam 2006). Recently, two species of *Nostoc* and four species of *Anabaena* are reported from paddy fields of Golestan and Guilan provinces of Iran (Nowruzi & Ahmadimoghadam 2006, Saadatnia & Riahi 2009). In this work, heterocystous BGA flora of four paddy fields in Guilan province are studied.

Materials and Methods

This study is focused on Guilan province which is located in the north of Iran, near the Caspian Sea and is the largest producer of rice in Iran. Soil samples were collected from four sites (Rostam Abad, Saravan, Omsheh, Rahim Abad) from April 2008 to January 2009 according to Rangaswamy (1996). The collected soil samples were transferred to sterile Petri dishes and sterilized nitrate free BG-11 medium (Stanier *et al*. 1971) was added and after sterilization, the pH adjusted to 7.1. The Petri dishes were placed in a growth chamber at 25° C and a 12/12 h light-dark cycle at artificial illumination (2000–2500 Luxes) for two weeks. After colonization, cyanobacteria were transferred to agar plates for purification. Taxonomic study was carried out by light microscopy and based on Desikachary (1959), Prescott (1970), Wehr *et al*. (2002) and Whitford & Schumacher (1973) by preparation of semipermanent slides. The vegetative and reproductive characters used in the taxonomic study were: Shape, colour and size of thallus; width and length of trichomes; shape, size and colour of vegetative cells, heterocysts and akinetes; as well as texture, colour and ornamentation of cell walls of the akinetes and heterocyst.

Results

In the present study, 22 taxa of heterocystous Cyanophyta were identified (Figs 3-6). *Nostocaceae* with six genera and 16 species, *Scytonemataceae* with two genera and three species and *Rivulariaceae* with one genus and three species presented among these taxa. The list of these taxa is as follows:

Nostocaceae

**Anabaena iyengarii* Bharadwaja

**Anabaena vaginicola* F.E. Fritsch & Rich

Anabaena sp.

**Aulosira fertilissima* Ghose

**Cylindrospermum michailovskoense* Elenkin.

Cylindrospermum majus Kützing

Nodularia spumigena Mertens.

Nodularia harveyana (Thwaites) Thuret.

**Nostoc ellipsosporum* var. *violaceum* C.B. Rao

Nostoc punctiforme (Kützing) Hariot

**Nostoc oryzae* (F.E. Fritsch) J. Komárek & K. Anagnostidis

**Nostoc paludosum* Kützing ex Bornet & Flahault

**Nostoc sphaericum* Vaucher ex Bornet & Flahault

Nostoc muscorum C. Agardh ex Bornet & Flahault

**Nostoc calcicola* (C. Agardh) C. Agardh

**Trichormus ellipsosporus* (F.E. Fritsch) Komárek & Anagnostidis

Scytonemataceae

**Tolypothrix bouteillei* (Brébisson & Desmazières) Lemmermann

**Tolypothrix distorta* Kützing ex Bornet & Flahault

Scytonema sp.

Rivulariaceae

**Calothrix marchica* Lemmermann

**Calothrix thermalis* (Schwabe) Hansgirg

**Calothrix elenkinii* Kossinskaja

* New records for Iran

Discussion

Cyanobacteria comprise a large group of structurally complex and ecologically significant gram-negative prokaryotes which flourish in rice paddies, and play a major role in sustaining the fertility of this ecosystem. Some cyanobacteria of soil have been shown to have remained viable for 18–107 years (Cameron

1962, Livingstone & Jawaraski 1980). Cyanobacterian research is a new matter in Guilan province and Iran as a whole. This survey showed the occurrence of 22 morphospecies of heterocystous cyanobacteria comprising of six genera and 16 species of *Nostocaceae*, two genera and three species of *Scytonemataceae* and one genus and three species of *Rivulariaceae* among which 14 species and one variety are new records for Iran. Among the families *Nostocaceae* with six genera and 16 species had the highest species richness (Fig. 1). *Nostoc* was found to be the dominant genus in all locations (Table 1). The overall generic diversity and percentage abundance is shown in Fig. 2. *Anabaena* strains are differentiated from *Nostoc* on the basis of their development of akinetes distance from the heterocyst (Prasanna *et al*. 2006). Taxonomically important characters of heterocystous cyanobacteria such as dimensions and shape of vegetative cells, heterocysts and akinetes, position of akinetes with regard to heterocyst and shape of terminal cells are hardly affected under different light and temperature conditions (Stulp 1982). Thus in this research these characters are used for identification of taxa. Among these characters, our observation is focused on stability of these characters. Only the size of cells, such as vegetative cells, heterocyst and spore, showed variability in different samples.

Table 1. Total percent abundance of cyanobacterial genera (summed up over all locations)

Genus	**Total No. of species**	**Percent abundance**
Anabaena	3	14%
Nostoc	7	32%
Aulosira	1	4.5%
Cylindrospermum	2	9%
Nodularia	2	9%
Trichormus	1	4%
Tolypothrix	2	9%
Scytonema	1	4.5%
Calothrix	3	14%
Total	22	100%

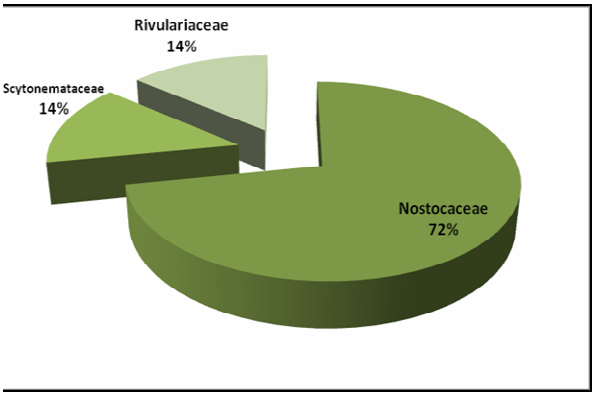

Fig. 1. Percent abundance of cyanobacterial families in paddy field of Guilan province.

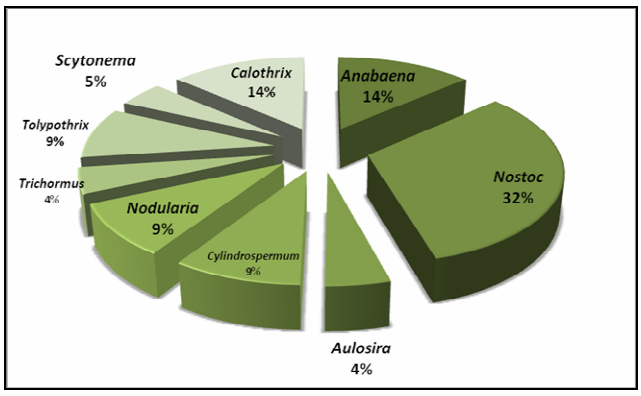

Fig. 2. Total percent abundance of cyanobacterial genera in paddy field of Guilan province.

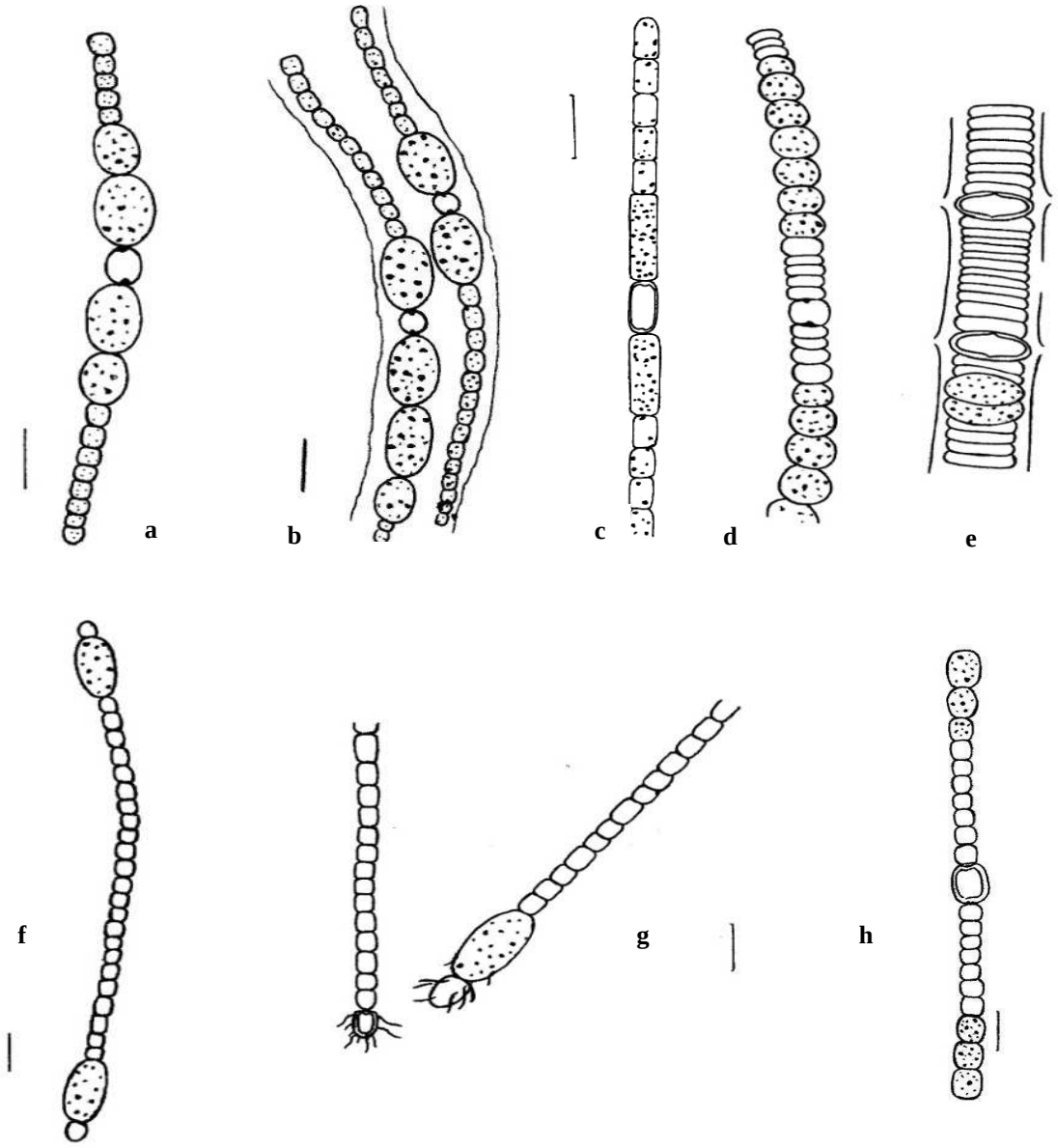

Fig. 3. a. *Anabaena iyengarii*, b. *A. vaginicola*, c. *A.* sp., d. *Nodularia.harveyana*,,e. *N.lspumigena*, f. *Cylindrospermumgmichailovskoense*,.g. *C.hmajus*, h. *Trichormus ellipsosporus* (Bar = 10 µm).

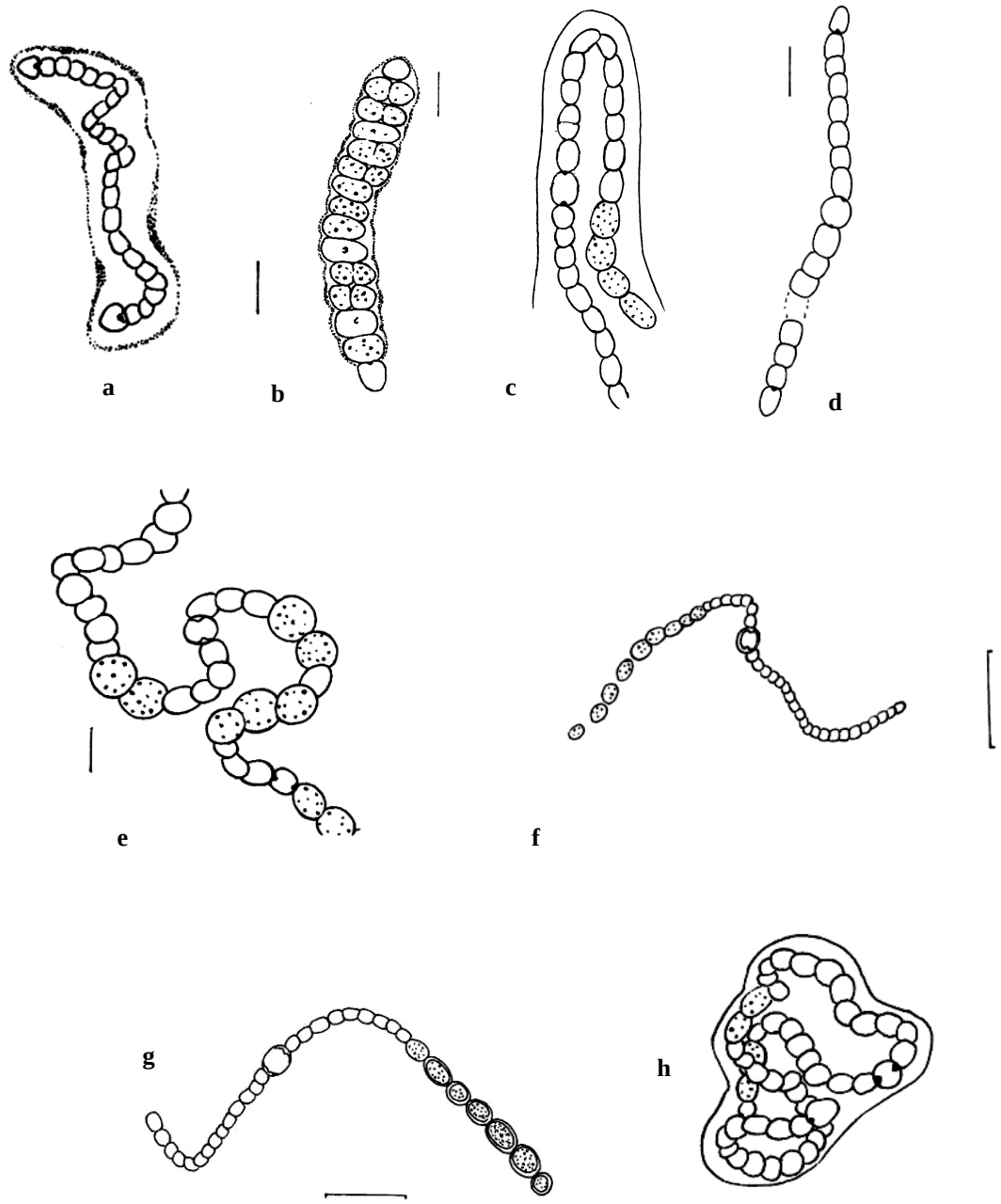

Fig. 4. a. *Nostoc paludosum*, b. *N. punctiforme*, c. *N. muscorum*, d. *N.-oryzae*,-e. *N.-sphaericum*,-f. *N.-calsicola*, g,-h. *N.-ellipsosporum* var. *violaceum* (Bar = 10 µm).

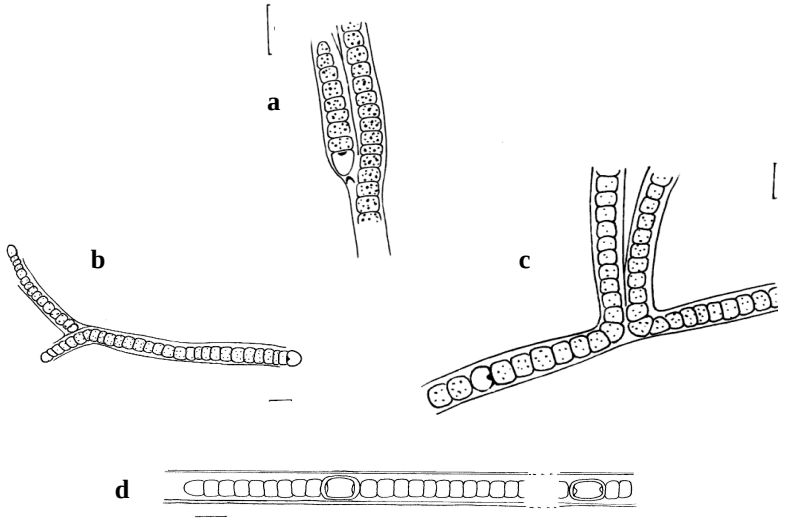

Fig. 5. a. *Tolypothrix distorta*, b. *Tolypothrix bouteillei*, c. *Scytonema* sp., d. *Aulosira fertilissima* (Scale = 10 µm).

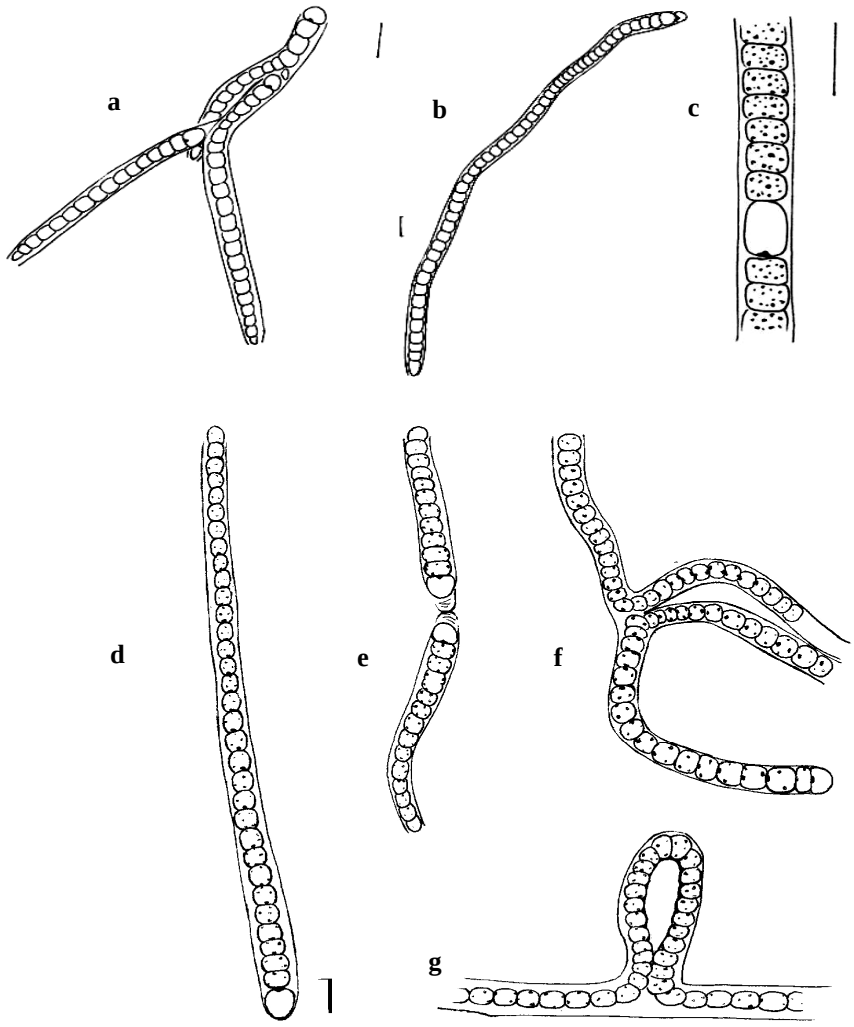

Fig. 6. a, b. *Calothrix elenkinii*, c. *C. thermalis*, d, e, f, g.- *C. marchica* (Bar = 10 µm).

Acknowledgments

Authors gratefully acknowledge the financial support of the University of Shahid Beheshti, Tehran, Iran. We also thank Dr. Shokravi, Dr. Soltani and Mr. Dadkhahipour for their assistance during the research.

References

Cameron, R.E. 1962. Species of *Nostoc* Vaucher occurring in the sonoran desert in Arizona. Trans. Am. Microsc. Soc. 81: 379–384.

Compere, P. 1981. Algues des desers d' Iran. Butt. Jard. Bot. Nat. Belg. 51: 3–40.

Desikachary, T.V. 1959. Cyanophyta. New Delhi: Indian Council of Agricultural Research. 686 pp.

Fritsch, F.E. 1907a. A general consideration of aerial and fresh water algal flora of Ceylon. Proceedings of the Royal Society of London, Series B 11: 79–197.

Fritsch, F.E. 1907b. The subaerial and freshwater algal flora of the tropics. Ann. Bot. 30: 235–275.

Livingstone, D. & Jaworski, G.H.M. 1980. The viability of akinetes of blue-green algae recovered from the sediments of Rostherne Mere. Br. Phycol. J. 15: 357–364.

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

Nowruzi, B. & Ahmadimoghadam, A. 2006. Two new records of heterocystus cyanobacteria (*Nostocaceae*) from paddy fields of Golestan province. Iran. Journ. Bot. 11(2): 170–173.

Oikarinen, M. 1996. Biological soil amelioration as the basis of sustainable agriculture and forestry. Biol. Fertil. Soils 22: 342–344.

Prasanna, R., Jaiswal, P. & Kaushik, B.D. 2008. Cyanobacteria as potential options for environmental sustainability-promises and challenges. Indian J. Microbiol. 48: 89–94.

Prasanna, R. & Nayak, S. 2007. Influence of diverse rice soil ecologies on cyanobacterial diversity and abundance. Wetlands Ecol. Manage. 15: 127–134.

Prasanna, R., Kumar, R., Sood, A., Prasanna, B.M. & Singh, P.K. 2006. Morphological, physiochemical and molecular characterization of *Anabaena* strains. Microbiol. Res. 161: 187–202.

Prasanna, R., Kumar, V., Kumar, S., Yadav, A.K., Tripath, U., Singh, A.K., Jain, M.C., Gupta, P., Singh, P.K. & Sethunathan, N. 2002. Methane production in rice soils is inhibited by cyanobacteria. Microbiol. Res. 157: 1–6.

Prescott, G.W. 1970. Algae of the western great lakes area. W.M.C. Brown Company Publishers. 977 pp.

Roger, P.A., Zimmerman, W.J. & Lumpkin, T.A. 1993. Microbiological management of wet land rice fields. Pp. 417–455. *In*: Soil microbial ecology: application in agricultural and environmental management. (Metting, B. ed.). Dekker, New York.

Rangaswamy, G. 1996. Agricultural microbiology. Asia Publishing House, Bombay, pp. 54–76.

Rippka, R., Deruelles, J., Waterbury, J.B., Herdam, M. & Stanier, R.Y. 1979. Generic assignments, strain histories and properties of pure cultures of cyanobacteria. J. Gen. Microbiol. 111: 1–61.

Saadatnia, H. & Riahi, H. 2009. Cyanobacteria from paddy fields in Iran as a biofertilizer in rice plants. Plant Soil Environ. 55(5): 207–212.

Singh, R.N. 1950. Reclamation of "usar" lands in India through blue-green algae. Nature 165: 325–326.

Stanier, R.Y., Kunisawa, R., Mandal, M. & Cohen-Bazire, G. 1971. Purification and properties of unicellular blue-green algae (order *Chroococcales*). Bacteriol. Rev. 35: 171–305.

Stulp, B.K. 1982. Morphological variability of *Anabaena* strains (Cyanophyceae) under different culture conditions. Arch. Hydrobiol. 63: 165–176.

Wehr, J.D., Sheath, R.G. & Thorp, J.H. 2002. Freshwater algae of north America: Ecology and classification. Aquatic Ecology Press. 917 pp.

Whitford, L.A. & Schumacher, G.J. 1973. A manual of fresh-water algae. Sparks Press, Raleigh, N.C. 337 pp.