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BLUE-GREEN ALGAE OF DIFFERENT RICE GROWING SOIL SERIES OF THE PUNJAB.

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Abstract

A survey of blue-green algae of rice growing areas of the Punjab, belonging to 12 different soil series was carried out. Of the 103 species belonging to 21 genera, more than 32 species belonging to 10 genera were heterocystous and are potential nitrogen fixers. They belong to the genera *Nostoc*(4 sp.) *Anabaena* (13 sp.), *Nodularia* (2 sp.), *Aulosira* (3 sp.), *Tolypothrix*(1 sp.), *Fortiea*(2 sp.), *Calothrix* (4 sp.), *Rivularia* (1 sp.), *Gloeotrichia* (1 sp.) and *Phormidium* (17 sp.) amongst non-heterocystous types, while *Anabaena*(13 sp.) and *Aulosira* (3 sp.) amongst the heterocystous types were most frequently observed in these soils. In the heterocystous types *Anabaena fertilissima* was the most commonly occurring algae in these soils.

Introduction

Nitrogen fixation is the only process by which fresh nitrogen from the atmosphere is added to the soil. According to an estimate, biologically fixed nitrogen is about four times more than that supplied by chemical nitrogen fertilizers of the world (Hardy & Havelka, 1975). Amongst the nitrogen fixing microbes, blue-green algae are photo-autotrophs and do not require preformed organic matter for nitrogen fixation as do bacteria like *Azotobacter* (Alexander, 1961). Although blue-green algae can grow in different environments they are common in rice fields. More than half of the world's population uses rice as a staple food. It is grown in an area of about one hundred million square kilometers distributed in different parts of the world like India, Pakistan, Far East, Southern Europe and United States. As most of the world's paddy fields have been supporting rice crop for centuries without the addition of artificial fertilizers, it is possible that nitrogen depletion by the rice crop is being replenished mainly by these algae (Fogg, *et al.*, 1973).

Beneficial effects of blue-green algae on soil properties and rice plant leading to increase in rice yield, due to their nitrogen fixation and liberation of some growth substances, have been reported from different parts of the world (Singh, 1950; El-Nawawy *et al.*, 1958; Bunt, 1961; Watanabe, 1951, 1966; IRRI Ann. Report, 1958; Sang *et al.*, 1970; Aiyer *et al.*, 1972). Nitrogen fixation of upto 70.8 lb/acre/6 weeks i.e. 613 lb/acre/year has been observed in rice soils by De & Mandel (1956). In India algal inoculation of

Table 1. Blue-green algal distribution in 12 soil series of rice growing area.

Genus	Total sp recorded	Number of species observed in soil culture of series											
		Shahpur	Gajiana	Bhalwal	Kotli	Miranpur	Pindorian	Gujranwala	Lyallpur	Missan	Pacca	Satghara	Hafizaba
A. Non-heterocystous genera:													
Chroococcus sp.	1	-	-	1	-	-	-	-	-	-	-	-	-
Aphanocapsa spp.	2	-	-	-	-	1	-	-	-	-	-	1	-
Aphanothece spp.	5	-	-	1	1	-	-	1	1	-	-	1	-
Synechococcus sp.	1	-	1	-	-	-	-	-	-	-	-	-	1
Hydrococ-cus sp.	1	1	-	-	-	-	-	-	-		-	-	-
Oscillatoria spp.	28	5	12	4	10	4	5	5	6	4	2	2	5
Phormidium spp.	17	12	6	9	6	8	8	8	6	5	3	4	3
Lyngbya spp.	10	3	3	-	-	3	1	4	-	1	1	-	-
Schizothrix sp.	1	-	1	-	-	-	-	-	-	-	-	-	-
Microcoleus spp.	4	3	-	-	-	-	1	-	-	-	-	-	-
Pseudanabaena sp.	1	1	-	-	-	-	1	-	1	-	1	-	-
B. Heterocystous genera:													
Nostoc spp.	4	1	-	-	1	1	-	-	2	1	1	-	1
Anabeena spp.	13	7	4	7	4	3	4	4	3	4	3	4	1
Nodularia spp.	2	-	-	-	-	-	-	-	1	-	-	1	-
Aulosira spp.	3	-	2	1	-	1	1	1	2	1	1	1	1
Tolypothrix sp.	1	1	-	-	-	1	-	-	-	-	-	-	1
Fortiea spp.	2	-	-	1	-	-	-	-	1	-	-	-	-
Calothrix spp.	4	4	1	1	2	2	3	1	-	-	2	-	1
Rivularia sp.	1	-	-	-	-	-	-	-	-	1	-	-	-
Gloeotrichia sp.	1	1	-	-	1	-	-	-	-	-	-	-	-
Hapalosiphon sp.	1	1	-	-	-	-	-	-	-	-	-	-	-
Total non-heterocystous genera	11	6	5	4	3	4	5	4	4	3	4	4	3
Total heterocystous sp.	10	5	3	4	4	5	3	3	5	4	4	3	5
Total non-heterocystous sp.	72	25	23	15	17	16	16	18	14	10	7	8	9
Total heterocystous sp.	32	14	7	10	8	8	8	6	9	7	7	6	5
Total genera	21	11	8	8	7	9	8	7	9	7	8	7	8
Total species	103	39	30	25	25	24	24	24	23	17	14	14	14

rice fields by spending only $0.5 on algal culture increased rice yields by 15.7% giving a benefit of about $48 per hectare over fertilizer alone (Venkataraman & Goyal, 1968). In Japan, Watanabe (1966) observed 2.23% increase in rice yields over a period of 5 consecutive years due to inoculation of *Tolypothrix tenuis*. He has quoted Singh who reported an increase in rice yield of 368% in pots and 114% in field conditions due to *Aulosira fertilissima*. Fogg *et al* (1973) have quoted Allen who observed upto 600% increase in rice yield under laboratory conditions due to Cyanophyceae.

These studies suggest that blue-green algae must also be playing an important role in rice fields of Pakistan, as conditions like abundant sunlight, low level of combined nitrogen and neutral to alkaline pH of the soil coupled with hot and humid climate of rice season are favourable factors which encourage the growth of blue-gree algae. The present investigation was carried out to study the distribution of blue-green algae of different soil series of rice growing areas of the Punjab.

Materials and Methods

For this survey 22 soil samples from 12 different soil series of rice growing areas of the Punjab were used. As more growth of blue-green algae in observed at the soil surface, therefore, top six inches of soil was sampled during the month of August. The chemical analysis of the soil samples and a brief description of these soil series alongwith equivalent 7th approximation and FAO classification system are given in Table 2. The nomenclature of these soil series alongwith detailed characteristics are available in soil series key by Rafiq (1969). One gram of soil from each soil sample was used for inoculation into 250 ml Erlenmeyer flasks containing 100 ml of the culture medium. Five different culture media as used by Khan (1957) to study the algae of rice fields of Kashmir and by Ali & Sandhu (1972) for the algal survey of saline soils were used. These differ in concentrations of different salts as well as in their composition, therefore, they provide a wide range of nutritional conditions and maximum types of algae are likely to grow as compared to inoculation of a soil into one culture medium only. Details of the method of growth and identification have been described previously (Ali & Sandhu, 1972).

Results and Discussion

After about 3 weeks of incubation there was macroscopic algal growth in most of the flasks. Microscopic examination revealed that the algal growth was mainly of Cyanophyceae except a unicellular member of Volvocales and two filamentous types belonging to the orders Ulotrichales and Oedogoniales. As regards the growth of different types of blue-green algae in these culture media, out of the 21 genera recorded in this study only 15 and 13 genera were observed in Beyyerink's and Uspenski's medium, respectively. Bristol's and Detmer's media helped the growth of 11 genera in each case while only 5 genera were recorded in Knop's culture medium. The Cyanophyceae observed in this survey consisted of more than 103 species belonging to 21 genera out of which more than 32 species belonging to 10 genera appeared to be potentially capable of fixing nitro-

gen as they contained heterocysts in their trichomes (Stewart *et al*. 1969; Fay, 1973; Round. 1973). It may be mentioned that a few strains belonging to non-heterocystous blue-green algae like *Gloeocapsa, Trichodesmium, Lyngbya, Phormidium, Raphidiopsis* and *Oscillatoria* can fix N_2 only under microaerobic conditions. Therefore, the number of nitrogen fixers is likely to be more than this figure, calculated on the basis of heterocystous strains. But the abundance of heterocystous algae has been regarded as an index of nitrogen fixation potential of a soil, and a good correlation has been observed in this respect (Stewart, 1973). Keeping this in view, the majority of nitrogen fixers being heterocystous, the algal types have been grouped into heterocystous and non-heterocystous types in this paper.

Table 2. Distribution of Blue-green algae with respect to soil series

Soil Series, Chemical Analysis, General Characters. 7th Approximation and F.A.O. equivalent	Types of Blue-green Algae Observed	
	Non-heterocystous	Heterocystous
1. SHAHPUR SERIES		
pH 7.1 to 8.2 EC0.9 to 4.5 O.M. 1.5 to 1.6 Brown silty clay to clay, moderately *to* strongly calcareous. 7th Approx: Typic Camborthids. F.A.O.: Haplic Xerosols.	1. *Hydrococcus rivularis* Kutz. 2. *Oscillatoria minnesotensis* Tilden *O. geitleriana* Elenkin *O. deflexa* W. & G.S. West *O. animalis* Ag. ex Gomont O. *acuminate* Gomont 3. *Phormidium* spp.(3) *P. angustissimum* W. & G.S.West *P. jenkelianum* Schmid, G. *P. abronema* Skuja P. *tenue* (Menegh.) Gomont *P. rubroterricola* Garner *P. bohneri* Schmidle *P. lurid-um(*Kutz.)Gomont *P. retzii* (Ag.) Gomont 4. *Lyngbya allorgei* Femy *L. Nigra* C. Ag. ex Gomont *L. martensiana* Menegh. ex Gomont	1. *Nostoc punctiforme* (Kutz.) Hariot. 2. *Anabaena sphaerica* Born. & Flah. 3. *A. spiroides* Klebahn *A. anomala* Fritsch *A. fertilissima* Rao, C.B. A. *iyengarii* Bharadwaja *Kutz. ex* Born & Flah. A. *variabilis* (Var. *ellipsospora* Fritsch) *A. circinalis* Tabenh ex Born.& Flah. 3. *Tolypothrix bouteillei* (Breb. & Desm.) Forti 4. *Calothrix* spp (3). *C. marchica* Lemm.

	5. *Microcoleus rupicola* (Tilden) Drouet 6. *M. paludosus* (Kutz.)Gomont *M. sub-torulosus(Breb.)Gomont* 7. *Pseudanabaena sch-midlei* Jaag, O.	5. *Hapalosiphon welwitschii* W. & G.S. West
2. GAJIANA SERIES pH 8.0 E.C. 3.3 O.M. 1.5 Yellowish-brown, saline alkali clay loam to silty clay loam, moderately to strongly calcareous. *7th Approx Halic Camborthids.* FAO: Haplic Xerosols.	1. *Synechococcus* sp. 2. *Oscillatoria spp.* (3). *O. subbrevis* Schmidle *O. curviceps* Ag. ex Gomont *O. subtilissima* Kutz. *O. jasorvensis* Vouk. *O. pseudogeminate* G. Schmid *O. Formosa* Bory ex Gomont *O. rubescens* DC ex Gomont *O. acuta* Bruhl et Biswas orth. mut. Geitler *O. brevis* (Kutz.)Gomont 3. *Phormidium angustissimum* W. & G.S. West *P. foveolarum(Mont.)Gomont* *P. mille*(Kutz.) Gomont *P. tennue*(Menegh.) Gomont *P luridum*(Kutz.) Gomont *P. payraceum(*Ag.)Gomont 4. *Lyngbya putealist* Mont. ex Gomont *L. patrikiana* Drouet *L. martensiana* Menegh. ex Gomont 5. *Schizothrix* sp.	1. *Anabaena sp.* *A. sphaerica* Born. *et* Flah. *A. anomala* Fritsch *A. variabilis* Kutz. ex Born. & Flah. 2. *Aulosira Laxa* Kirchner ex Born. & Flah. *A. pseudoramosa* Bharadwaja *3. Calothrix wembaerensis* Hireon. et Schmidle
3. BHALWAL SERIES pH 8.0 E.C. 2.0 to 1.3 O.M. 1.2 to 1.3 Dark yellowish Brown, moderately calcareous, silty clay loam to clay loam. 7th Approx: *Typic Camborthids.* FAO:Haplic *Exerosols.*	1. Chroococcus sp. 2. *Aphanothece calathrata* W. & G.S. West 3. *Oscillatoria subbrevis* Schmidle *O. limnetica* Lemm. *O. angusta* Koppe *O. animalis* Ag. ex Gomont 4. *Phormidium* sp. *P. angustissimum* W. & G.S. *West* *P. fragile*(Menegh.) Gomont	1. *Anabaena* spp.(3) 2. *A. fertilissima* Rao, C.B. *A. iyengarii* Bharedwaja *A. dolium* Bharadwaja *A. laxa*(Rabenh.) A. Br. 2. *Aulosira* sp. 3. *Aulosira* sp. 4. *Calothrix javanica* De Wilde

P. foveolarum(Mont.)Gomont
P. molle(Kutz.) Gomont
P. laminosum Gomont
P. tenue(Menegh.) Gomont
P. cebennense Gomont
P. luridum (Kutz.) Gomont

4. KOTLI SERIES

pH 7.5 to 8.0
E.C. 1.3
O.M. 0.8 to 1.4
Yellowish brown non to slightly calcareous soil.
7th Approx: Udorthentic Chromusterts.
FAO: Vertisols

1. *Aphanothece* sp.
2. *Oscillatoria* sp.
   O. vizigapatensis Rao, C.B.
   O. subbrevis Schmidle
   O. curviceps Ag. ex Gomont
   O. jasorvensis Vouk.
   O. mougeotii Kutz.
   O. Pseudogeminata G. Schmid
   O. amphibia ag. ex Gomont
   O. rubescens DC ex Gomont
   O. agardhii gomont
3. *Phormidium* sp.
   P. angustissimum W. & G.S.West
   *P. foveolarum(Mont.)*Gomont
   P. molle(Kutz.) Gomont
   P. tenue(Menegh.) Gomont
   P. Luridum (Kutz.) Gomont

1. *Nostoc* sp.
2. *Anabeena anomala* Fritsch
3. *A. fertilissima* Rao, C.B.
   A. orientalis Dixit
   A. variabilis (Kutz. ex Born. & Flah.
3. *Calothrix* sp.(2)
4. *Gloeotrichia raciborskii* Woloszynska

5. MIRANPUR SERIES

pH 7.3 to 7.8
E.C. 1.3 to 1.5
O.M. 0.8 to 1.3
Yellowish to greyish brown, slightly to non-calcareous, clay to silty clay.
7th Approx: Aquic Ustochrepts.
FAO: Eutric Cambisols.

1. *Aphanocapsa elachista* W. & G.S. West
2. *Oscillatoria* sp.
   O. minnesotensis Tilden
   O. pseudogeminata G.Schmid
   O. animalis Ag. ex Gomont
3. *Phormidium* sp.
   P. angustissimum W. & G.S.West
   P. jenkelianum Schmid, G.
   P. tenue(Menegh.)Gomont
   P. rubroterriocola Gardner
   P. luridum(Kutz.)Gomont
   P. yalderianum (Delp.)Gomont
4. *Lyngbya birgei* Smith, G.M.
   L. martensiana Menegh. ex Gomont

1. *Nostoc* sp.
2. *Anabaena aphanizomenoides*
   A. variabilis Kutz. ex Born. & Flah.
   A. torulosa (Carm.) Lagerh. ex Born. & Flah.
3. *Aulosira* sp.
4. *Tolypothrix bouteillei* (Breb. et Desm.)Forti
5. *Calothrix* spp. (2).

6. PINDORIAN SERIES

pH 8.0 to 8.1
E.C. 0.9 to 2.0
O.M. 1.1 to 1.26

Yellowish to brown.

non-calcareous, sandy clay loam to loam.

7th Approx:Udic Haplustalfs.

FAO:Haplic

Luvisols.

1. *Oscillatoria mougeotii* Kutz.
   O. minnesotensis Tilden
   O. amphigranulate van Goor
   O. pseudogeminata G.Schmid
   O. geitleriana Elenkin
2. *Phormidium* spp.(2)
   P. angustissimum W. & G.S.West
   *P. foveolarum (*Mont.) Gomont
   P. molle (Kutz.)Gomront
   P. molle(F.*tenuir* W. & G.S. West)
   P. jenkelianum Schmid. G.
   P. tenue (menegh.) Gomont
   P. luridum (Kutz.) Gomont
3. *Lyngbya martensiana* Menegh. ex Gomont
4. *Microcoleus* sp.
5. *Pseudanabaena Schmidlei* Jaag. O. (f.*gracilis* Skuja)

1. *Anabaena.* sp.
   .*A. anomala* fritsch
   A. fertilissima Rao, C.B.
   A. variabilis Kutz. ex Born. et. Flah.
2. *Aulosira laxa* Kirchner ex Born. et Flah.
3. *Calothrix* spp.(2)
   C. membranacea Schmidle.

7. GUJRANWALA SERIES

pH 8.4
E.C. 1.0
O.M. 0.8
Dark yellowish brown, non or slightly calcareous, silty clay loam to silt loam
7th Approx: Udic Haplustalfs.
FAO: Haplic *Luvisols.*

1. *Aphanothece naegellii* Wartm.
2. *Oscillatoria hemellii* Femy
   O. angusta Koppe
   O. pseudogeminata G.Schmid
   O. quadripunctulata Bruhl. et Biswas. (Var. *unigranulata* Singh, R.N.)
   O. animalis Ag. ex Gomont
3. *Phormidium angustissimum* W. & G.S. West
   P. molle (Kutz.) Gomont
   P. abronema Skuja
   P. tenue (Menegh) Gomont
   P. rubroterricola Gardner
   P. valderianum (Delp.) Gomont
   P. minnesotensis (Tilden) Drouet
4. *Lyngbya hieronymusii* Lemm.
   L. digueti Gomont
   L. semiplena (C.Ag.) J. Ag. ex Gomont
   L. martensiana Menegh. ex Gomont

1. *Anabaena* sp.
   A. anomala Fritsch
   A. ftertilissima Rao, C.B.
   A. variabilis Kutz. ex Born. et Flah.
2. *Aulosira aenigmatica* Fremy
3. *Calothrix marchica* Lemm.

8. LYALLPUR SERIES:

pH 7.7 E.C. 11.2 O.M. 1.3 Dark yellowish brown, calcareous, silt loam to silty clay loam. 7th Approx: Typic Camborthids. FAO:Haplic Yermosols.	1. *Aphanothece microscopica* Nag. 2. *Oscillatoria annae* van Goor *O.Subbrevis* Schmidle *O.foreaui* Fremy *O.jasorvensis* Vouk. *O.Pseudogeminata* Schmid, G. *O.brevis* (Kutz.) Gomont 3. *Phormidium angustissimum* W. & G.S. West *P.foveolarum* (Mont.) *Gomont* *P.jenkelianum* Schmid, G. *P. tennue* (menegh.) Gomont *P.rubroterricola* Gard-ner *P.luridum* (Kutz.) Gomont 4. *Pseudanabaena schmidlei* Jaag, O.	1. *Nostoc punctiforme* (Kutz.) Hariot *N. commune* Vaucher ex Born. *et* Flah. 2. *Anabaena* sp. *A.fertilissima* Rao, C.B. *A.oscillarioides* Bory ex Born. *et* Flah. 3. *Nodularia spumigena* Mertens ex Born. *et* Flah. 4. *Aulosira* sp. *A. aenigmatica* Fremy 5. *Fortiea bossei* (Fremy) comb. nov.

9. MISSAN SERIES:

pH 8.4 E.C. 3.4 O.M. 1.5 Yellowish brown, saline alkali, clay, moderately to strongly calcareous. 7th Approx: Typic Comborthids. FAO: Haplic Xerosols.	1. *Oscillatoria subbrevis* Schmiddle *O.jasorvensis* Vouk. *O.formosa* Bory ex Gomont *O.animalis* Ag. ex Gomont 2. *Phormidium angustissimum* W.& G.S. West. *P. foveolarum* (Mont.) Gomont *P.luridum* (Kutz.) Gomont *P.corium* (Ag.) Gomont *P.papyraceum* (Ag.) Gomont 3. *Lyngbya birgei* Smith, G.M.	1. *Nostoc paludosum* Kutz. ex Born. et Flah. 2. *Anabaena anomala* Fritsch *A. fertilissima* Rao, C.B. Born. & Flah *A.variabilis* Kutz. ex Born. & Flah. (var.) *ellipsospora* Fritch) *A. oscillarioides* Bory ex Born. & Flah. 3. *Aulosira laxa* Kirch-ner Born. & Flah. 4. *Rivularia bornetiana* Setchell

10. PACCA SERIES:

pH 7.9 E.C. 2.9 O.M. 1.4 Light to distinct Yellowish brown, silty clay to clay moderately calcareous.	1. *Oscillatoria pseudogeminata* G. Schmid *O.animalis* Ag. ex Gomont 2. *Phormidium foveolarum* (Mont.) *P.tenue* (Menegh.) Gomont	1. *Nostoc* sp. 2. *Anabaena anomala* Fritsc *A.fertilissima* Rao, C.B. *A.variabilis* Kutz. ex Born. & Flah.

7th Approx: Aquic Ustochrepts. FAO: Calcic Cambisols.		*P.luridum* (Kutz.) Gomont	3. *Aulosira aenigmatica* Femy
	3.	*Lyngbya limnetica*	4. *Calothrix* sp.
	4.	*Pseudanabaena Schmidlei* Jaag, O. (f.*gracilis* Skuja)	*C.marchica* Lemm.

11. SATGHARA SERIES:

pH 8.1 to 8.2	1.	*Aphanecapsa montana* Gramer	1. *Anabaena* sp.
E.C. 2.0 to 2.3	2.	*Aphanothece pallida* (Kutz.) Rebenh.	*A.anomala* Fritsch
O.M. 0.7 to 1.4			*A.fertilissima* Rao, C.B.
Brown, saline alkali	3.	*Oscillatoria amphibia* Ag. ex Gomont	A.variablis Kutz. ex Born. & Flah.
silty clay to clay		*O.animalis* Ag. ex Gomont	
7th Approx: Typic	4.	*Phormidium angustissimum* W. &G.S.West	2. *Nodularia harveyana* (Thwaites) Thuret
Halorthids.		*P.tenue* (Menegh.) Gomont	3. *Aulosira sp.*
FAO: Orthic Solonetz.		*P.luridum* (Kutz.) Gomont	
		P. papyraceum (Ag.) Gomont	

12. HAFIZABAD SERIES:

pH 8.1	1.	*Synechococcus sp.*	1. *Nostoc microscopicum* Carm.ex Born. & Flah.
E.C. 2.6	2.	*Oscillatoria chlorina* Kutz. ex Gomont	2. *Anabaena* sp.
O.M. 0.97		*O.foreaui* Fremy	3. *Aulsoria* sp.
Brown to dark brown moderately		*O.jasorvensis* Vouk.	4. *Tolyporhrix bouteillei* (Breb. et Desm.) Forti
to strongly calcareous loam (loam to sandy loam)		*O.amphigranulata* van Goor	
		O.angustissima W.&G.S.West	5. *Calothrix* sp.
	3.	*Phormidium angustissimum* W.& G.S. West	
7th Approx: Typic Camborthids.		*P.molle* (Kutz.) Gomont	
FAO: Haplic Xerosols.		*P.tenue* (Menegh.) Gomont	

NOTE:- E.C. = Electrical conductivity expressed in m mhos/cm at 25°C
O.M.= Organic matter expressed in percentage.
( )= Figure in the brackets indicates unidentified species.

There were more than 71 species belonging to 11 genera which lacked heterocysts (Table 1). This shows that at least 31% of the observed species of blue-green algae in these soil series were probably nitrogen fixers. The Shahpur soil series was the richest in total blue-green algal types (39 sp.). Gajiana, Pindorian, Kotli, Bhalwal, Gujranwala, Miranpur and Lyallpur series had 30,24,25,25,24.24 and 23 species respectively. The remaining soil series of Missan (17 sp.), Hafizabad (14 sp.), Satghara (14 sp.) and Pacca (14 sp.) were poor in blue-green algal types. As regards the distribution of heterocystous types Shahpur series had the maximum number (14 sp.), while the rest had between 7-9 species except

for Hafizabad which had 5 species (Tables 1 & 2). *Oscillatoria, Phormidium* and *Lyngbya* among the non-heterocystous genera, while *Anabaena, Aulosira, Calothrix* and *Nostoc* among the heterocystous genera were most commonly distributed in these soils. Of the heterocystous types, *Anabaena fertilissima* was the most commonly distributed alga in these soils (Table 2).

Similar types of blue-green algae have also been reported in paddy fields of other countries. *Tolypothrix* and *Calothrix* have been reported from U.A.R.(El-Nawawy *et al.*, 1958), *Nostoc, Anabaena* and *Tolypothrix* have been reported from rice soils of the Philippines (IRRI Annual Report, 1968), *Nostoc, Anabaena, Tolypothrix* and *Calothrix* were found in a survey of Java, Sumatra, Borneo, the Philippines, Malaysia, Indo-China Manchuria, Korea, Sakhalin, and Japan (Watanabe, 1966). The blue-green algae like *Nostoc commune, N. punctiforme, Anabaena anomala, A. fertilissima, A. variabilis* var. *ellipsospora, A. torulosa, A. oscillarioides, Aulosira* sp., *Tolypothrix bouteillei, Calothrix* sp., and *Hapalosiphon welwitschii* amongst heterocystous types and *Aphanothece pallida, Oscillatoria curviceps, O.geitleriana, O.animalis, Phormidium foveolarum, P.molle, P. angustissimum, P.jenkelianum, P.tenue, P.valderianum, P.corium, P.fragile, P.laminosum, Lyngbya birgei* and *Microcoleus* amongst the non-heterocystous types have also been reported growing in rice fields or cultures of soils of the rice fields of India and Faridpur (Singh, 1950; Desikachary, 1959; Daradhiyar & Daradhiyar, 1970; Aiyer, 1972). Khan (1957) also found *Aphanocapsa, Chroococcus, Synechococcus, Oscillatoria, Phormidium molle, Lyngbya semiplena* and *L.putealis* amongst non-heterocystous and *Nostoc, Anabaena, Aulosira* and *Calothrix* amongst the heterocystous Cyanophyceae growing in culture of the soils of the rice fields of Kashmir. *Phormidium, Lyngbya, Nostoc* and *Anabaena* have been observed in Australian rice fields, and it is interesting that *Anabaena* was as ubiquitous as in our rice fields (Bunt, 1961). We have now recorded the presence of 10 heterocystous genera i.e. *Nostoc, Anabaena, Nodularia, Aulosira, Tolypothrix, Fortiea, Calothrix, Rivularia, Gloeotrichia* and *Hapalosiphon* belonging to the order Nostocales in the soils of the rice fields of the Punjab. This shows that blue-green algae of rice fields in different parts of the rice growing countries of the world appear to be similar to some extent.

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