CYANOPHYCEAN FLORA OF SOME NORTH INDIAN CROP-FIELDS

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ABSTRACT

Taxa of blue-green algae from fields of twelve different crops of north India have been enumerated. In addition, data pertaining to pH, rainfall, humidity and temperature have also been incorporated. A total of two hundred and twelve taxa have been described as occurring in the crop-fields studied.

INTRODUCTION

In field studies of Cyanophyceae, we are largely at the level of Turril's "alpha-taxonomy" (TURRIL, 1938). This is especially true for studies on the algal flora of crop-fields of the Indian sub-continent where large tracts still remain unexplored. It was considered desirable to investigate the algal vegetation so that the forms occurring here may be first documented and recorded. Very scanty information is available regarding the nature, distribution, differences and variations in the algal flora of different kinds of crop-fields of India (c.f. MITRA, 1951 ; DUTTA & VENKATARAMAN, 1958 and GONZALVES & YALAVIGI, 1959). It is not known adequately whether the algal flora of crop-fields supporting different kinds of crops also varies or whether the type of crop has no interacting influence on the spectrum of the algal flora in a particular field. It was thought desirable to compare and see whether the algal vegetation in different fields differs significantly and, if so, in what salient features ? Such a correlation is considered useful also to agricultural scientists. The results obtained in the form of new taxa, new records from India, first records from Uttar Pradesh and taxa occurring in different crop-fields add considerably to our knowledge.

The present work covers the studies on Cyanophycean flora of different types of crop-fields of Uttar Pradesh, India. In all, 212 taxa recorded principally from nature and from cultures of field soils have been described. An attempt has been made to study the different taxa with particular reference to their respective distribution in different crop-fields of India and the ranges of pH in which they occur.

Soil algae including Cyanophyceae are helpful in reclamation of alkaline ('Usar') soils (SINGH, 1950, 1961) and play an important role in the soil-complex by their growth, extracellular products, death and decay and stabilization action of the surface layer, reducing soil erosion (DADHICH *et al.*, 1969 ; ELVELL, SLOSSAR & DANIEL, 1939). They help to improve infiltration (BOOTH, 1941), make a suitable substrate for the growth of other plants of macro-vegetation since the bulk of the organic matter produced by the algal growth is retained by the soil (FRITSCH, 1907 ; ALEKSANDROVA, 1951).

The C : N in blue-green algae is considerably low as a result of which decomposition leads to the immediate production of NH_3 (SHIELDS & DURRELL, 1964). Certain forms are also known to have a solvent action on soil minerals (CHODAT, 1928) and keep a reserve supply of the ions of different salts in a semi-available form for other macro-vegetation (MARTIN, 1949).

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AIYER *et al.* (1972) reported a significant reduction in the contents of oxidisable matter, total sulphides and ferrous iron in Kerala (India) soils as a result of repeated algalisation.

The possibility of growth substances and vitamins produced by blue-green algae having a role in increasing crop yield was advocated by VENKATARAMAN (1965) and VENKATARAMAN AND NEELKANTAN (1967). Prior to it, production of vitamin B12 has been conclusively shown for algae (OKUDA & YAMAGUCHI, 1960). Algae also synthesize auxin-like growth-promoting substances which help in crop growth. This aspect of blue-green algae supplying vitamins and growth-promoting substances promotes the likelihood of non-nitrogen-fixing forms as being of agricultural importance too. *Phormidium* has been shown to stimulate plant growth in case of rice (GUPTA & SHUKLA, 1964, 1967 and GUPTA & KUSUMLATA, 1964), wheat, (GUPTA & KUSHWAHA, 1972 ; KUSHWAHA & GUPTA, 1970) and pea (GUPTA & GUPTA, 1970). The role of extracellular organic substances liberated by the blue-green algae in the surrounding medium is particularly important as chelating agents (c.f. VENKATARAMAN, 1972).

A number of blue-green algae increase soil-phosphate (FULLER & ROGERS, 1952) and help in providing soil oxygen to the roots of higher plants (HARRISON & AIYAR, 1913).

RUSSEL (1923) states that the volume occupied by algae in soil is almost three times the volume occupied by bacteria and that a gram of manured soil may contain as many as 1,000,000 algal cells.

Since members of Cyanophyceae fix atmospheric nitrogen, considerable work has been done regarding the isolation and screening of the soil algae with special reference to their ability for fixing atmospheric nitrogen (DE, 1939 ; BORTELS, 1940; FOGG, 1942, 1947, 1951, 1962, 1969 and FOGG *et al.*, 1973 ; SINGH, 1942, 1961 ; BURRIS & WILSON, 1946 ; WILLIAMS & BURRIS, 1952 ; RELWANI *et al.*, 1953 ; DE & MANDAL, 1956 ; WATANABE, 1959 ; SUBRAHMANYAN & SAHAY, 1964 and PATTNAIK, 1966, etc.) So far, fifty-two species or strains of blue-green algae are known to fix atmospheric nitrogen. Out of these, there are ten non-heterocystous forms, nine strains, two unspecified species while the remaining are heterocystous determined species (c.f. FOGG *et al.*, 1973) ; a majority of these are known to occur in India (VENKATARAMAN, 1972).

A perusal of the literature on the Cyanophycean flora of different crop-fields of India reveals that SINGH (1939, 1950 and 1961), GONZALVES AND GANGLA (1949), MITRA (1951), GUPTA (1957, 1964), KHAN (1957), DUTTA AND VENKATARAMAN (1958), GONZALVES AND YALAVIGI (1959), MARATHE AND NAVALKAR (1962-63), MARATHE (1964, 1966-67), PANDEY (1965a, 1965b), PANDEY AND MITRA (1965), DADHICH *et al.*, (1969), SHUKLA (1971), TEWARI (1972) and GUPTA AND KUSHWAHA (1972) have studied this aspect with special reference to paddy fields. MITRA (1951) studied the algal flora of wheat and paddy fields and red soils. DUTTA AND VENKATARAMAN (1958) did some exploratory work on cultivated and uncultivated soils, GONZALVES AND YALAVIGI (1959) studied the Cyanophycean flora of cotton, wheat and 'Jowar' (*Sorghum vulgare* L.) rhizospheres, GUPTA (1964) and GUPTA *et al.*, (1964, 1967, 1970) studied the effect of extracts of some blue-green algae on seed germination and growth of certain crop-plants and DADHICH *et al.*, (1969) studied the effect of *Calothrix* inoculations on vegetable crops. It is also a well-established fact that the soils of India have a dominant community of blue-greens (c.f. MITRA, 1951 ; VAIDYA, 1965 ; PANDEY, 1965a; SUBBA RAJU, 1967, 1972 and PRASAD AND SRIVASTAVA, 1968). Taxonomic studies are a pre-requisite to further work and understanding of the problems and the processes involved. Since information available pertaining to the Cyanophycean flora of various crop-fields is inadequate, the present investigation helps to fill a gap in our knowledge.

MATERIAL AND METHODS

In the present work, soil and algal samples were collected from time to time in different seasons from different localities over a period of four years between April 1971 and October 1975.

(*a*) Types of crop-fields—For purpose of the study, twelve different types of crop fields were chosen for collection. The different fields were : wheat (*Triticum aestivum* L.), 'Jowar' (*Sorghum vulgare* Pers.), gram (*Cicer arietinum* L.), maize (*Zea mays* Mill.), paddy (*Oryza sativa* L.), linseed (*Linum usitatisimum* L.), 'arhar' (*Cajanus cajan* (L) Mill), mustard (*Brassica campestris* L.), pea (*Pisum sativum* L.), cauliflower (*Brassica oleracea* var. *botrytis* L.), tomato (*Lycopersicum esculentum* L.) and potato (*Solanum tuberosum* L.).

(*b*) Collection of soil samples—The samples were taken from the surface up to 15 cm (6") depth with sterilized spatula and kept tightly in polythene bags with proper labelling. Petersen (1935) and Fritsch (1936) observed that the surface algae are washed down to deeper layers and Bristol-Roach (1928) showed in the soils obtained from different depths at Rothamsted, England that the algal flora was distributed laterally. Hence, the layer up to 15 cm (6") only was chosen. The soil samples were brought to the laboratory for algal culturing and observations. A total of 212 taxa were encountered growing in these fields or in laboratory cultures. A total of 125 collections were made out of which there were 21 samples from wheat, 4 from 'Jowar', 9 from gram, 3 from maize, 54 from paddy, 3 from linseed, 4 from 'arhar', 9 from pea, 3 from mustard, 5 from cauliflower, 4 from tomato and 6 from potato fields.

(*c*) Collection of Algal samples—Collections from fields were made in clean glass bottles fitted with corks after proper labelling. Although present communication covers Cyanophycean forms only, other algae were also collected (to be published later). The collections were later examined microscopically on the day of collection and later on after preserving the material in 4 per cent formalin solution.

(*d*) pH, humidity, rainfall and temperature—In all soil samples and water (algal) samples the pH was determined with the help of narrow-range BDH indicator paper in the field. Data regarding humidity, rainfall and temperature were obtained through the kind courtesy of the Regional Meterological Station of the Govt. of India. The data have been given in figures 1-3.

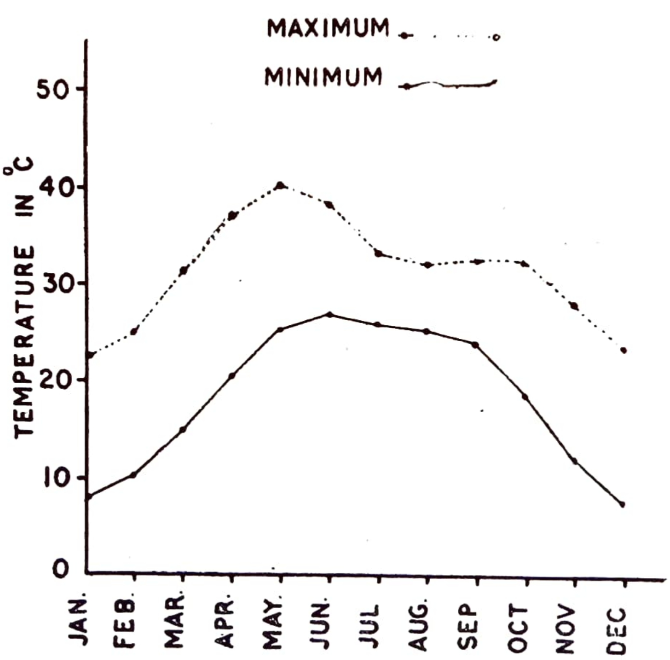

Fig. 1. Graph showing average minimum and maximum temperature (1971-1975).

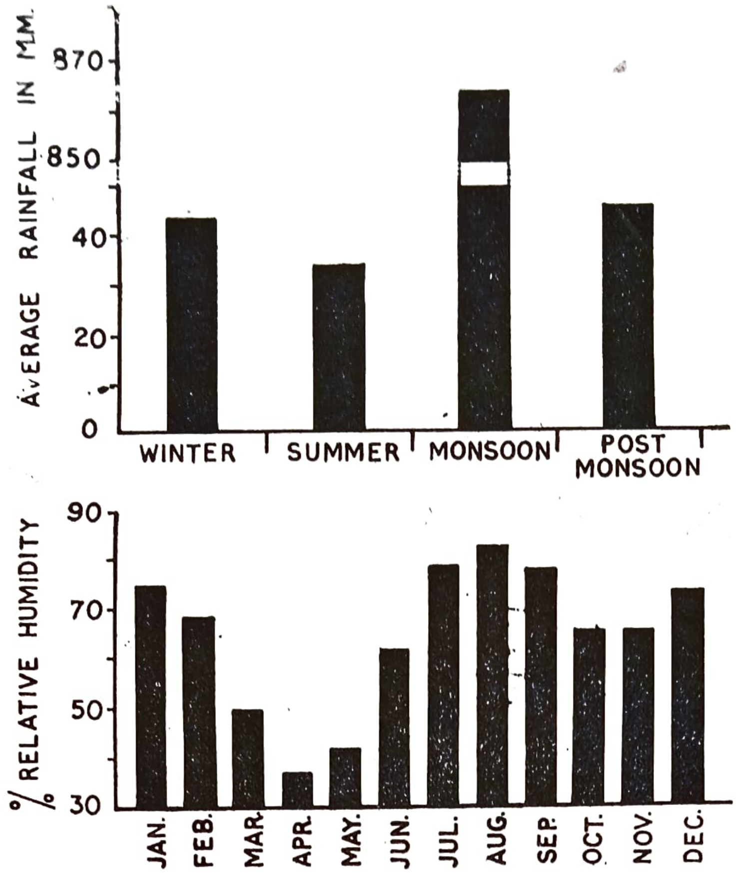

Fig. 2. Histogram showing the average of rainfall and relative humidity (1971-1975).

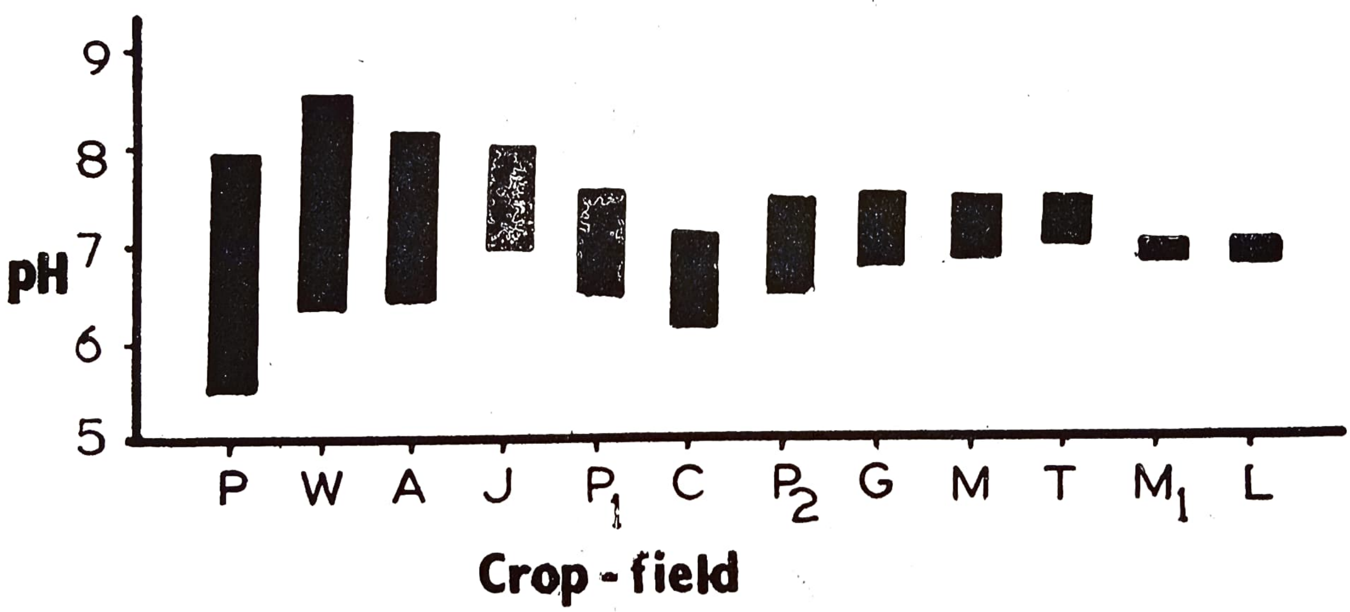

Fig. 3. Histogram showing pH range of crop-fields.
Abbreviations : P=Paddy ; W=Wheat ; A='Arhar' ; J=Jowar ; P^1=Pea ; C=Cauliflower ; P^2=Potato G=Gram ; M=Mustard ; T=Tomato ; M^1=Maize ; L=Linseed.

De's (1939) and Allen and Arnon's (1952) solutions were found most suited for enrichment to raise forms in the soil-water enrichment cultures, hence, these solutions were employed extensively, also in the form of "agar" plates in petri-dishes and slants in test-tubes prepared with the addition of 1 per cent agar.

All the glasswares and culture solutions were autoclaved at 15 lbs per square inch pressure for 15 minutes, one day prior to use. Inoculations were done with needles after proper sterilisations with 90 per cent Ethyl Alcohol and over a Bunsen flame.

The culture vessels were placed generally in open culture cabinets fitted with fluorescent tubes and time switches. Equal dark and light periods were properly maintained. The intensity of light in the various culture cabinets varied from approximately 300-600 foot candles. The cultures were maintained at room temperature up to 16 weeks and examined periodically and regularly for forms that came up.

The identifications are based mostly on the material collected in nature and also on forms observed in cultures of field soils. The classification of various taxa has been done in accordance with the system adopted by DESIKACHARY (1959).

SYSTEMATIC ENUMERATION

1. Wheat fields :

Microcystis aeruginosa, *M. stagnalis*, *Gloeocapsa crepidinum*, *G. nigrescens*, *Gloeothece rupestris*, *G. samoensis* var. *major*, *Aphanothece microscopica*, *Chlorogloea microcystoides*, *Myxosarcina spectabilis*, *Oscillatoria boryana*, *O. brevis*, *O. limosa*, *O. obscura*, *O. sancta*, *O. violacea*, *Phormidium abronema*, *P. ambiguum*, *P. anomala*, *P. angustissimum*, *P. autumnale*, *P. calcicola*, *P. cebennense*, *P. corium*, *P. favosum*, *P. foveolarum*, *P. fragile*, *P. molle*, *P. valderianum*, *Lyngbya connectens*, *L. nordgardhii*, *L. rubida*, *L. spiralis*, *L. versicolor* var. *undulata*, *Microcoleus acutissimus*, *M. chthonoplastes*, *Nostoc commune*, *N. parmelioides*, *Scytonema javanicum*, *S. mirabile*, *Microchaete calothrichoides* f. *major*, *M. tenera*, *Calothrix membranacea*, and *Hapalosiphon welwitschii*.

2. Jowar fields :

Gloeocapsa crepidinum, *Aphanocapsa biformis*, *Phormidium angustissimum*, *P. favosum*, *P. molle*, *Lyngbya confervoides*, *L. lagerheimii f. lacerata*, *L. martensiana*, *L. martensiana* var. *minor*, *Microcoleus chthonoplastes*, *Calothrix castellii* var. *somastipurense* and *C. clavatoides*.

3. Gram fields :

Gloeocapsa atrata, *Aphanocapsa gigantea*, *Oscillatoria acuta*, *O. amoena*, *O. brevis*, *Phormidium foveolarum*, *P. laminosum*, *P. luridum*, *P. mucosum*, *P. papyraceum*, *P. purpurascens*, *P. tenue*, *Lyngbya semiplena*, *Nostoc calcicola*, *N. commune*, *N. piscinale*, *N. rivulare*, *N. sphaericum*, *Scytonema hofmanii*, *Calothrix contrarenii*, *Hapalosiphon intricatus* and *H. hibernicus*.

4. Maize fields :

Chroococcus montanus, *Spirulina princeps*, *Oscillatoria laete-virens*, *O. terebriformis*, *Phormidium molle*, *P. tenue*, *Lyngbya aestuarii*, *L. ceylanica*, *L. dendrobia* and *Calothrix contarenii*.

5. Paddy fields :

Microcystis aeruginosa, *M. litoralis*, *M. protocystis*, *M. robusta*, *M. stagnalis*, *Chroococcus minor*, *C. minutus*, *C. montanus*, *C. pallidus*, *C. schizodermaticus*, *C. turgidus*, *Gloeocapsa atrata*, *G. crepidinum*, *G. rupestris*, *Gloeothece membranacea*, *G. rupestris*, *Aphanocapsa banaresensis*, *A. biformis*, *A. elachista* var. *conferta*, *A. grevillei*, *A. roseana*, *Aphanothece microscopica*, *A. naegelii*, *A. pallida*, *Chlorogloea microcystoides*, *Myxosarcina spectabilis*, *Xenococcus acervatus*, *Arthrospira gomontiana*, *A. platensis* var. *non-constricta*, *Spirulina princeps*, *Oscillatoria acuta*, *O. acutissima*, *O. amoena*, *O. anguina* var. *variabilis*, *O. boryana*, *O. brevis*, *O. limosa*, *O. laete-virens*, *O. martini*, *O. minnesotensis*, *O. nigra*, *O. obscura*, *O. rubescens*, *O. salina*, *O. sancta*, *O. subtilissima*, *O. terebriformis*, *Phormidium abronema*, *P. ambiguum*, *P. anomala*, *P. angustissimum*, *P. calcicola*, *P. cebennense*, *P. cincinnatum* var. *capitatum*, *P. corium*, *P. favosum*, *P. foveolarum*, *P. fragile*, *P. gyralis*, *P. laminosum*, *P. luridum*, *P. molle*, *P. molle* f. *tenuior*, *P. mucosum*, *P. mucicola*, *P. retzii*, *P. rubroterricola*, *P. tenue*, *P. usterii*, *Lyngbya aerugineo-coerulea*, *L. aestuarii*, *L. bergei*, *L. ceylanica*, *L. connectens*, *L. connectens* f. *granulata*, *L. corberei*, *L. cryptovaginata* f. *major*, *L. hieronymusii* var. *crassivaginata* *L. kuetzingiana*, *L. lagerheimii*, *L. lucknowensis*, *L. major*, *L.majuscula*, *L. martensiana*, *L. martensiana* var. *calcarea*, *L. putealis*, *L. putealis* f. *multigranulata*, *Schizothrix arenaria*, *Microcoleus acutissimus*, *M. acutissimus* f. *minor*, *M. chthonoplastes*, *Cylindrospermum muscicola*, *C. muscicola* forma, *C. michailovskoense*, *Nostoc austinii*, *N. calcicola*, *N. calcicola* f. *variabilis*, *N. carneum*, *N. citrisporum*, *N. coeruleum*, *N. comminutum*, *N. commune*, *N. depressum*, *N. ellipsosporum*, *N. ellipsosporum* f. *minor*, *N. glomeratum*, *N. hatei*, *N. humifusum*, *N. linckia*, *N. linckia* var. *arvense*, *N. minutum*, *N. paludosum*, *N. paludosum* var. *majus*, *N. piscinale*, *N. rivulare*, *N. sphaericum*, *N. spongiaeforme*, *N. spongiaeforme* var. *tenuis*, *N. verrucosum*, *N. wartisporum*, *Anabaena ambigua*, *A. catenula*, *A. fertilissima*, *A. iyengarii*, *A. iyengarii* var. *tenuis*, *A. inaequalis*, *A. khannae*, *A. naviculoides* var. *minuta*, *A. oryzae*, *A. orientalis* var. *ellipsospora*, *A. variabilis var. ellipsospora*, *A. vaginicola*, *A. volzii*, *Nodularia spumigena*, *Aulosira fertilissima*, *A. fertilissima* var. *tenuis*, *A. pseudoramosa*, *Scytonema bohneri*, *S. hofmanii*, *S. javanicum*,*S. mirabile*, *S. ocellatum*, *S. tolypothrichoides*, *S. varium*, *Tolypothrix tenuis*, *Microchaete loktakensis*, *M. tenera*, *M.violacea*, *M. uberrima*, *Calothrix braunii*, *C. castellii*, *C. castellii* var. *somastipurense*, *C. clavatoides*, *C. elenkinii*, *C. lucknowense*, *C. marchica*, *C. marchica* var. *intermedia*, *C. membranacea*, *C. parietina*, *Rivularia nitida*, *Gloeotrichia ghosei*, *Nostochopsis lobatus*, *Hapalosiphon delicatulus*, *H. intricatus*, *H. welwitschii* and *Westiellopsis prolifica*.

6. Linseed fields :

Arthrospira gomontiana, *Oscillatoria nigroviridis*, *O. sancta*, *Phormidium abronema*, *P. cebennense*, *Lyngbya aerugino-coerulea*, *L. martensiana*, *Nostoc linckia* var. *arvense*, *N. sphaeroides* and *Anabaena variabilis*.

7. Arhar fields :

Aphanocapsa elachista var. *conferta*, *Myxosarcina spectabilis*, *Oscillatoria acuta*, *O. amoena*, *O. limosa*, *Phormidium luridum*, *P. tenue*, *Lyngbya confervoides*, *Nostoc amplissimum*, *N. commune*, *N. humifusum*, *N. microscopicum* and *Hapalosiphon hibernicus*.

8. Pea fields :

Chroococcus minor, *Dermocarpa hemisphaerica*, *Oscillatoria acuta*, *O. amoena*, *O. boryana*, *O. nigra*, *O. obscura*, *O. quadripunctulata*, *O. sancta*, *Phormidium abronema*, *P. angustissimum*, *P. autumnale*, *P. corium*, *P. jenkelianum*, *P. molle*, *P. rubroterricola*, *Lyngbya allorgei*, *L. borgerti*, *L. magnifica*, *Microcoleus chthonoplastes*, *Nostoc ellipsosporum*, *N. rivulare* and *N. sphaericum*.

9. Mustard fields :

Chroococcus montanus, *Spirulina princeps*, *Phormidium foveolarum*, *P. papyraceum*, *Lyngbya conferoides*, *L. martensiana*, *Microcoleus acutissimus*, *Nostoc calcicola* f. *variabilis*, *N. microscopicum*, *N. sphaericum*, *Anabaena variabilis* var. *ellipsospora*, *Cylindrospermum majus*, *Tolypothrix nodosa* and *Calothrix castellii*.

10. Cauliflower fields :

Gloeocapsa nigrescens, *Aphanocapsa biformis*, *Aphanothece naegelii*, *A. pallida*,*Oscillatoria nigra*, *Phormidium cebennense*, *P. jenkelianum*, *P. tenue*, *Lyngbya aestuarii*, *L. aerugineo-coerulea*, *L. cryptovaginata*, *L. nordgardhii*, *Nostoc aureum*, *N. carneum*, *Aulosira prolifica*, *Scytonema ocellatum*, *Calothrix brevissima* and *C. membranacea*.

11. Tomato fields :

Aphanocapsa banaresensis, *A. grevillei*, *Phormidium foveolarum*, *P. jenkelianum*, *P. mucicola*, *P. retzii*, *P. rubroterricola*, *Lyngbya martensiana*, *Nostoc sphaeroides*, *N. verrucosum*, *N. calcicola*, *N. linckia*, *Anabaena ambigua*, *Aulosira fertilissima*, *Calothrix braunii*, *C. marchica*, *Hapalosipon intricatus* and *Westiellopsis prolifica*.

12. Potato fields :

Gloeothece samoensis var. *major*, *Gloeocapsa nigrescens*, *Aphanocapsa grevellei*, *Oscillatoria boryana*, *O. acuta*, *O. terebriformis*, *O. violacea*, *Phormidium luridum*, *P. valderianum*, *P. fragile*, *Lyngbya aestuarii* var. *bitrichomata*, *L. limnetica*, *Microcoleus acutissimus*, *Nostoc ellipsosporum* var. *violacea*, *N. spongiaeforme*, *Anabaena ambigua*, *Fortiea incerta*, *Calothrix brevissima* and *C. membranacea*.

DISCUSSION

On comparison of the various taxa observed from the various types of crop-fields during present investigations, with the work done by other workers (SINGH, 1939, 1961; MITRA, 1951; GUPTA, 1957; and PANDEY, 1965a) by and large, the earlier observations are on paddy fields. Most of the genera and species are common. But if the present findings are subjected to comparison with that from other regions in India, it is found that the Cyanophycean flora varies quite appreciably (BANERJI, 1935; DE, 1939; GONZALVES & GANGLA, 1949; KHAN, 1957; MARATHE, 1964; MARATHE & NAVALKAR, 1963 and TIWARI, 1972).

BANERJI (1935) recorded 7 taxa of blue-green algae from rice fields of Bengal, three of which have also been observed by us, the taxa being : *Phormidium corium*, *P. luridum* and *Nostoc commune*. Another common taxon *Phormidium valderianum* reported from paddy fields of Bengal has been recorded here from wheat fields.

SINGH (1939), while studying the algal flora of paddy fields of Mirzapur, Varanasi, Gorakhpur and Basti districts of Uttar Pradesh, obtained 14 species of Cyanophyceae belonging to eight genera. Most of the taxa have been observed in the present study also. However, a few, e.g. *Homoeothrix juliana* forma *tenuis*, *Gloeotrichia intermedia* forma, *Oscillatoria variabilis*, *O. proboscida* forma, *O. quadripunctulata* var. *unigranulata* and *Lyngbya limnetica*, were not observed from paddy fields during present work although three taxa namely *Homoeothrix juliana*, *Oscillatoria quadripunctulata* forma and *Lyngbya limnetica* have been found to occur in other crop-fields in present investigations.

DE (1939) recorded 4 new species of *Anabaena* from paddy fields of Faridpur, Bengal and *Phormidium foveolarum*, the latter taxon is common in the present study too.

GONZALVES AND GANGLA (1949) obtained 33 taxa of blue-green algae of which 6 taxa have also been observed during present work. The taxa are : *Phormidium foveolarum*, *Lyngbya aestuarii*, *L. aerugineo- coerulea*, *Nostoc linckia* and *Scytonema hofmanni*, while a variety of *Oscillatoria anguina* has been found by us in place of the main species.

MITRA (1951) while working on the algal flora of certain Indian soils had taken soil samples from four different types of rice field soils. If the present work is compared with his findings on the four paddy fields collectively, it is observed that most of the taxa are common except the following reported by Mitra : *Phormidium corium* f. *terrestre*, *P. hieronymusii* f. *major*, *P. allahabadii*, *P. tenue* var. *indica*, *Aphanothece saxicola*, *Chroococcus westii* var. *terrestris*, *Lyngbya iyengarii*, *L. rubida* (this taxon has been found from wheat fields during present work), *L. hieronymusii* var. *major* (*L. hironymusii* var. *crassivaginata* has been observed by us) *L. aerugineo-coerulea* var. *terrestris* (*L. aerugineo-coerulea* during present work) *L. nigra* var. *gelatinosa*, *L. iyengarii* var. *violacea*, *Oscillatoria formosa*, *O. princeps*, *Anabaena allahabadii*, *Chlorogloea fritschii* (*C. microcystoides* during present work), *Nostoc linckia* var. *globispora* (*N. linckia* during present work), *N. paludosum* var. *major* (*N. paludosum* and *N. paludosum* var. *majus* during present work), *Calothrix anomala*, *Camptylonema lahorense* var. *allahabadii* and *Fischerella mucicola* var. *indica*.

GUPTA (1957) described 47 taxa of blue-green algae from paddy fields of Uttar Pradesh. Most of the taxa found by him have also been observed by the present authors except the following : *Chlorogloea fritschii* (*C. microcystoides* in the present work), *Phormidium frigidum*, *P. papyraceum* (This taxon is observed from gram and mustard fields in present work), *Lyngbya nigra*, *L. oryzae*, *L. spirulinoides*, *Porphyrosiphon notarisii*, *Anabaena bharadwajae*, *Nostoc passerianum*, *N. punctiforme*, *Aulosira fritschii*, *Gloeotrichia natans*, *Plectonema tomasinianum* var. *gracile*, *P. puteale*, *Scytonema coactile*, *Tolypothrix distorta* var. *penicillata*, *Camptylonema lahorense*, *C. indica* var. *allahabadii* and *Fischerella mucicola*.

The investigations of KHAN (1957) on the algal flora of paddy fields of Kahsmir included 35 Cyanophycean members. Our results differ with his findings, perhaps because the fields undertaken during present investigations are situated in the plains whereas Kashmir fields are situated at high elevations affording different temperate conditions.

SINGH (1961) observed some 25 species of blue-green algae from various paddy fields of India. He stated that the rice fields of U. P. and Bihar afford a richer flora of blue-green algae than other groups. Some of the common species are : *Aphanothece pallida*, *Microcoleus chthonoplastes*, *Nostoc humifusum*, *Cylindrospermum muscicola*, *Scytonema hofmanni* and *S. ocellatum*.

MARATHE (1964) and MARATHE AND NAVALKAR (1963) observed 31 taxa of Cyanophyceae during an investigation on the effect of fertilizers on the sub-terranean algal flora of paddy field soils from Karjat, Maharashtra, eight of them were also found in the present study. The species are : *Oscillatoria limosa*, *Phormidium foveolarum*, *P. angustissimum*, *Cylindrospermum muscicola*, *Nostoc humifusum*, *N. linckia*, *N. carneum* and *Hapalosiphon welwitschii*.

PANDEY (1965a) also studied the algal flora of various paddy fields of Uttar Pradesh and recorded 74 various taxa. Many of his forms are common e.g., *Chroococcus turgidus*, *C. minutus*, *C. pallidus*, *Aphanocapsa grevillei*, *Aphanothece pallida*, *A. naegelii*, *Oscillatoria obscura*, *O. laete-virens*, *Phormidium angustissimum*, *P. fragile*, *P. mucicola*, *P. foveolarum*, *P. molle* f. *tenuior*, *P. tenue*, *P. rubroterricola*, *P. luridum*, *P. autumnale*, *Lyngbya lagerheimii*, *L. aestuarii*, *L. aerugineo coerulea*, *Microcoleus chthonoplastes*, *M. auctissimus*, *Cylindrospermu muscicola*, *Nostoc linckia*, *N. sphaericum*, *Aulosira fertilissima*, *Scytonema hofmanni*, *S. ocellatum*, *Tolypothrix nodosa* (From mustard field during present work) and *Calothrix membranacea*.

TIWARI (1972) studied the algal flora of four states viz. Madhya Pradesh, Maharashtra, Karnataka and Tamil Nadu and obtained 132 various forms of blue-green algae collectively from soil samples and from nature. The common forms are : *Microcystis aeruginosa*, *M. littoralis*, *M. protocystis*, *Gloeocapsa atrata*, *G. rupestris*, *Gloeothece somoensis* var. *major*, *Aphanocapsa grevillei*, *Aphanothece naegelii*, *Oscillatoria brevis*, *O. limosa*, *Phormidium angustissimum*, *P. foveolarum*, *P. luridum*, *P. mucicola*, *P. tenue*,*P. rubroterricola*, *Lyngbya aerugino-coerulea*, *L. bergei*, *L. martensiana*, *L. majuscula*, *L. lagerheimii*, *Microcoleus acutissimus*, *M. chthonoplastes*, *Cylindrospermum muscicola*, *Nostoc paludosum*, *N. linckia*, *N. linckia* var. *arvense*, *N. humifusum*, *N. carneum*, *N. ellipsosporum*, *Anabaena iyengarii*, *A. vaginicola*, *A. ambigua*, *Aulosira fertilissima*, *A. prolifica* var. *tenuis*, *A. pseudoramosa*, *Tolypothrix tenuis*, *Microchaete uberrima*, *Calothrix membranacea*, *C. marchica* var. *intermedia*, *Gloeotrichia ghosei*, *Hapalosiphon fontinalis*, *Hapalosiphon welwitschii* and *Westiellopsis prolifica*.

On comparing the present findings from wheat fields with those of MITRA (1951), it is observed that during present investigation 43 taxa were observed belonging to 15 genera while MITRA (1951) described 19 taxa belonging to 9 genera. Most of the taxa observed by him have not been found in the present work. However, the algae which have been found to be common to both the investigations are, *Phormidium foveolarum*, *P. autumnale*, *Lyngbya rubida*, *Microcoleus chthonoplastes*, *Scytonema ocellatum* and *Calothrix membranacea*.

GONZALVES AND YALAVIGI (1959) recorded 15 taxa belonging to 9 genera from rhizospheres of wheat, the only common taxa are : *Oscillatoria sancta* and *Phormidium foveolarum*. It is worth mentioning here that out of 15 taxa recorded by them, 8 taxa were observed from other crop-fields during the present work but not from wheat fields as reported by them. The taxa which are common considering all types of crop-fields are : *Chroococcus turgidus*, *Oscillatoria sancta*, *Phormidium foveolarum*, *Lyngbya aestuarii*, *Nostoc sphaericum*, *Nostoc carneum*, *Anabaena fertilissima* and *Calothrix marchicha*.

GONZALVES AND YALAVIGI (1959) had observed 18 taxa from 'Jowar' (*Sorghum vulgare*) rhizospheres while 12 taxa are recorded during the present work. Most of the genera are common but no single species has been found to be common in both works.

It is thus, clear that generally the floristic patterns of various paddy fields situated in Uttar Pradesh are alike while a significant change is observable comparing the flora of paddy fields with other regions of the country. PANDEY (1965a) and SUBBA RAJU (1972) had also drawn attention to the differences in algal flora in different regions and they thought it to be due to varying physico-chemical (ecological) factors.

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