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SUCCESSION OF ALGAL FLORA IN DEEP WATER RICE FIELD OF SONARGAON, BANGLADESH

Z.N. Tahmida Begum, R. Mandal* and Ashit Ranjan Paul
Department of Botany, University of Dhaka, Dhaka 1000, Bangladesh

ABSTRACT

Influence of some environmental factors on the succession of algae in deep water rice field ecosystem has been observed. Field study suggests that both chemistry of water and fertility of soil significantly affect the growth of algal population. pH, dissolved O_2, total alkalinity and free carbon dioxide content of the water had a dominant effect on the succession of algae.

INTRODUCTION

Considerable work has been done in different countries on the positive role of algae in enriching the fertility of rice soils. In India soil based algal inoculum is being used as a supplement for nitrogenous fertilizers (Venkataraman 1977 and 82; Goyal, 1987). Roger and Reynaud (1976) made a study of population dynamics of algae during a growing season in an inundated rice field in Senegal and showed predominance of eukaryotic algae followed by prokaryotic algae. In Philippines, Watanabe and his associates (1977) showed that during the dry season, algal density was highest just after heading of the rice crop and during the wet season, development was maximum after harvesting. Recently the ecophysiological and technological aspects of algae with special reference to rice field ecosystem have been comprehensively reviewed by Roger and Kulasooriya (1980) and Venkataraman (1981; Goyal, 1987). In Bangladesh some experimental work on the effect of algae on rice yield has been done by Bhuiya *et al.* (1980-81) and Begum and Islam (1982). Whitton (1984) reported the role of water chemistry on algal vegetation and biological nitrogen fixation in deep water rice fields of Bangladesh,

In the present investigation an effort was made to study the significance of chemistry of water and soil on the qualitative and quantitative distribution of algae in deep water rice field (DWRF).

*Department of Social Science, University of Dhaka, Dhaka 1000, Bangladesh.

MATERIAL AND METHODS

A field experiment was carried out at Sonargaon about 15 miles away from Dhaka during pre-flooded, flooded and post-flooded seasons with three experimental sites under old Brahmaputra flood plain. Fields were prepared with recommended dose of urea and 2 weeks old seedlings of T. Aman (Khama) rice were transplanted on 25-4-1985.

The field data and water sample and algal material collection were made at weekly intervals. Freshly deposited soil samples (10-15 cm) were collected every fortnight for pH, nitrogen and phosphorus analysis. The chemistry of flood water inside and immediately adjacent to DWR fields was investigated and data were collected on temperature, pH, depth and turbidity of water and height of rice plants. Besides depth profile of temperature was recorded after every fortnight.

Conductivity, free CO_2, dissolved O_2, total alkalinity of the water sample were determined by following standard analytical techniques. Soil N was estimated by Kjeldahl method and P was measured colorimetrically after developing phosphomolybdoyellow acid complex.

RESULTS AND DISCUSSION

A. Water Chemistry

Time of sampling was between 10 am and 1.30 pm. Water depth, plant height and temperature in the field varied significantly during sampling (Table 1). However, the variation between sample sites was found to be statistically non significant. Sun shine was highly variable.

Changes in pH and dissolved O_2 in water during flooded period was statistically non significant (Table 2). However, conductivity, total alkalinity and free CO_2 content were found to differ significantly. A significant variation between sample sites was also recorded in the chemistry of water except in acidity. Conductivity, total alkalinity and dissolved O_2 varied from 41 to 62 25 to 42 and 5.6 to 8.8 mg/l respectively and that of pH from 5.2 to 7.2. Free CO_2 content was 20 to 42 mg/l from middle of July to first week of August, thereafter its concentration reduced drastically to 6 mg/l and remained almost unchanged except in few cases upto the month of October.

As expected pH, total alkalinity, dissolved O_2 and free CO_2 were found to depend on time of day and the relative rates of photosynthesis and respiration. Temperature depends on the input and loss of radiant energy. Content of N in the soil increased slightly, values for P rather remained same before and after flooding. During flooded period P content decreased slightly (Table 3).

TABLE 1. Physical variables of different sites in DWR fields during 1984.

Date	Time			Water depth (cm)			Plant height (cm)			Temp (c°)			Sun		
	S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3
12.7.84	12.15	13.00	13.30	1.37	1.52	1.31	1.49	1.58	1.37	30.0	30.0	30.0	Bright	Bright	Bright
20.7.84	12.30	13.15	14.00	1.98	2.13	1.92	2.10	2.22	1.98	31.0	31.0	31.0	Bright	Bright	Bright
26.7.84	12.00	13.30	12.00	2.11	2.28	1.98	2.60	2.60	2.45	33.0	30.0	33.5	Shade	Shade	Shade
5.8.84	12.50	13.20	13.50	2 74	2.89	2.65	2.04	3.04	2.92	31.5	31.5	31.5	Bright	Bright	Bright
11.8.84	9.00	9.30	10.00	2.74	2.89	2.65	3.20	3.20	3.04	32.0	32.0	32.0	Bright	Bright	Bright
18.8.84	11.00	11.30	12.00	1.92	2.07	1.82	3.40	3.40	3.20	32.2	32.5	32.5	Rainy day	Rainy day	Rainy day
31.8.84	10.00	10.30	11.15	1.60	1.73	1.49	3.54	3.54	3.25	32.0	32.0	32.5	Shade	Shade	Shade
9.9.84	10.15	10.40	11.10	1.82	1.98	1.70	3.75	3.79	3.65	32.5	33.0	33.2	Dark	Shade	Shade
16 9.84	11.30	12.10	12.40	2.13	2.28	1.82	3.81	3.82	3.68	33.0	34.0	34.0	Shade	Shade	Shade
23.9.84	11.10	11.40	12.10	2.37	2.51	2.19	3.88	3.87	3.72	32.5	33.0	33.2	Bright	Bright	Bright
31.9.84	10.00	10.30	11.10	1.76	1.88	1.61	3.90	3.88	3.74	31.0	32.0	32.5	Heavy cloud	Heavy cloud	Heavy cloud
9.10.84	10.00	10.30	11.10	0.91	1.03	0.76	3.91	3.90	3.75	31.0	31.2	31.8	Bright	Bright	Bright
20.10.14	10.10	10.40	11.15	0.51	0.64	0.39	3.92	3.92	3.80	31.0	31.5	32.0	Rainy day	Rainy day	Rainy day
Average				1.84	1.98	1 72	3.20	3.21	3.15	31.74	31.80	32.30			
LSD at 5 % level				0.05	0.02	0.03	0.04	0.03	0.6	0,05	0.04	0.07			

TABLE 2. Chemical variables of different sites in DWR fields during 1984.

Date	pH			Conductivity (us cm-1)			Total alkalinity (mg/l)			D. O_2 (mg/l)			Free CO_2 (mg/l)		
	S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3	S-1	S-2	S-3
12.7.84	5.8	5.4	5.4	48	45	45	28	27	35	7.3	7.5	7.8	24	24	25
20.7.84	5.2	5.3	5.3	44	42	45	35	30	25	7.0	7.2	8.0	25	20	25
26.7.84	6.5	6.8	6.5	44	34	42	40	28	32	7.0	7.0	7.8	25	30	27
5.8.84	7.1	6.6	7.0	45	45	45	42	40	30	7.7	8.0	7.1	42	38	30
11 8.84	6.8	6.5	6.6	46	45	42	30	30	32	7.1	5.6	6.3	5	25	25
18.8.84	7.2	6.8	7.1	62	54	62	30	29	30	6.0	6.4	6.2	7.5	7.5	7.5
31.8.84	6.8	6.8	6.8	45	41	43	31	30	35	5.9	5.7	5.9	6	6	6.6
9.9.84	7.0	6 8	7.0	42	45	48	30	31	31	5.7	5.6	6.7	6	6	6.0
16.9.84	7 0	7.1	7.0	45	45	45	30	30	30	6.0	5.8	6.5	6	6.5	6.8
23.9.84	7.1	7.0	7.1	46	44	47	30	32	35	6.0	6.6	5.9	6	8.0	7.5
31.9.84	7.0	6.7	7.1	52	50	51	30	25	40	6.0	6.2	6.1	6	8.5	8.0
9.10.84	6.7	6.9	6.9	55	56	54	30	35	42	6.2	6.5	6.0	6.7	8.8	19.2
20.10.84	6.7	7.7	7.0	58	58	58	43	30	28	7.2	5.9	8.8	6.8	10.0	16
Average	6.7	6 59	6.67	48.6	46.5	48.2	33	30 5	32.7	6.7	6.5	6.9	13.2	15.3	16 12
LSD at 5% level	NS	NS	NS	2.3	2.8	3.1	1.8	1.2	0.8	NS	NS	NS	3.8	2.8	3 0

TABLE 3. Changes in nitrogen and phosphorus content of soil during 1984.

Sample area	Pre-flooded		Flooded		Post-flooded		Average	
	% N	ppm P.	% N	ppm P	% N	ppm P	% N	ppm P
Site — 1	0.145	425	0.164	375	0.158	425	0.156	408
Site — 2	0.147	425	0.171	375	0.142	425	0.172	408
Site — 3	0.164	415	0,167	410	0.174	430	0.168	418
Average	0.152	422	0,167	387	0.158	427	0.165	411
LSD at 5%	0.33	NS	0.08	3.25	0.03	NS	0.04	NS

TABLE 4. Relative abundance of algal population inside DWR fields at Sonargaon during 1984 (July-December)

Taxon	Pre-flooded			Genus	Flodded			Genus	Post-flooded			Genus
	S-1	S-2	S-3	total	S-1	S-2	S-3	total	S-1	S-2	S-3	total
CHLOROPHYCEAE												
Coleochaete	1	2	1	4	6	3	2	11				
Oedogonium	2	2	1	5	10	9	7	26	5	2	3	10
Bulbochaete					6	2	3	11				
Oocystis	1	2	1	4	3	2	0	5				
Zygnema					2	1	2	5				
Spirogyra					1	5	2	8				
Cosmarium					7	4	4	15	1	2	1	4
BACILLARIOPHYCEAE												
Fragilaria	2	1	1	4	7	6	7	20				
Navicula	1	1	2	4	6	3	5	14	1	1	1	3
Pinnularia	3	3	2	8	7	6	4	17				
CYANOPHYCEAE												
Nostoc	1	2	2	5	4	2	3	9	2	1	1	4
Anabaena					7	7	5	19	4	2	3	9
Aulosira	2	1	1	4	5	1	2	8	3	2	2	7
Scytonema	1	2	2	5	1	1	1	3	4	3	2	9
Calothrix					5	2	1	8				
Rivularia					4	4	2	10				
Gloeotrichia					6	7	5	18				
Algal population	14	16	13	43	87	65	55	207	20	13	13	46
LSD at 5% level	0.21	0.10	0.12		1.11	1.41	1.36		0.33	0.10	0.47	

TABLE 5. Coefficients of correlation calculated between algae and chemistry of water and soil.

Water variable / Algae	Water depth	Temp.	pH	Dis-solved D-O_2	Alkali-nity	Conduc-tivity	Free CO_2	Flooded N	Flooded P	Pre-flooded N	Pre-flooded P	Post-flooded N	Post-flooded P
Nostoc	−0.54	+0.55	−0.01	−0.66	+0.88	+0.57	−0.89	+0.99	0.01	+0.82	+0.91	+0.01	+0.50
Anabaena	+0.87	−0.98	+0.84	−0.12	+0.46	−0.83	+0.46	−0.50	+0.36			+0 48	+0 001
Aulosira	+0.24	−0.37	−0.22	+0.84	+0.72	+0.17	−0.68	+0 93	+0.24	+0.76	−0.09	+0 01	+0.50
Scytonoma	+0.64	+0.59	+0.37	+0.48	+0.66	+0.72	+0.64	0.00	0.00	+0.82	−0.49	−0.50	−0.86
Calothrix	+0.49	+0.47	−0.11	+0.99	+0.99	+0.31	+0.15	+0.79	+0.86				
Rivularia	+0.82	−0.73	−0.57	−0.13	−0.48	+0.79	+0.16	+0.56	−0.37				
Gloeotrichia	+0.99	−0.97	+0.70	+0.54	+0.92	−0.96	+0.53	+0.57	+0.99				
Coleochaete	+0 20	+0.80	−0.99	+0.93	0.26	+0.46	+0.32	+0.68	−0.97	+0.25	+0.89		
Oedogonium	+0.61	−0.97	+0.99	−0.02	+0.14	+0.70	+0.15	−0.72	+0.94	+0.70	+0.99	+0.002	+0.18
Bulbochaete	+0.59	+0.36	+0.98	+0.84	+0.90	+0.59	−0.72	+0.92	+0.98				
Spirogyra	+0.75	+0.26	+0.52	+0.41	+0.62	=0.33	+0.81	+0.99	+0.27				
Cosmarium	+0.01	−0.57	−0.99	−0.94	+0.62	+0.07	−0.59	+0.83	+0.86				
Fragilaria	+0.87	−0,28	+0.93	−0.20	+0.99	+0.83	+0.10	+0.47	+0.86				
Navicula	−0.56	0.12	−0.96	−0.66	+0.88	+0.43	−0.89	+0.99	−0.89	+0.19	+0.36	+0.01	+0.01
Pinnularia	+0.62	−0.97	−0.97	−0.0?	+0.14	−0.70	−0.99	−0.78	+0.99				

B. Algal Vegetation

The relative abundance of algae in the rice field is recorded in Table 4. Both individual and total algal population distributed in the fields showed a significant variation at all the stages of flooding. Abundance of algae was more or less same in post-flooded and flooded rice field than pre-flooded condition. The growth of algal population increased by about 4.5 times during flooded period as compared to other two stages.

During pre-flooding, 9 genera of algae were found in the field of which the most dominant genus was *Pinnularia*, a member of Bacillariophyceae (Table 4). However, in the post-flooded field most of the algal genera as found in the pre-flooded field were evident togther with the genus *Cosmarium* belonging to family Chlorophyceae.

During flooding 17 types of algae were recorded (Table 4). The abundant genera were *Coleochaete*, *Oedogonium*, *Cosmarium*, *Fragilaria*, *Navicula*, *Pinnularia*, *Anabaena* and *Gloeotrichia*. Moderately occurring genera were *Bulbochaete*, *Oocystis*, *Spirogyra*. *Nostoc*, *Aulosira*. *Calothrix* and *Rivularia*.

The results showed that a few algae which were present during pre-flooded period completely disappeared in post flooded soil. Contrary to this, a good number of algae appeared only in the flooded period. The algal population identified in the rice field belonged to the family Chlorophyceae, Bacillariophyceae and Cyanophyceae.

The abundance of algae in the DWR fields was found to vary greatly from place to place and to a lesser extent with time during the flood period. The algal vegetation was found to be abundant during following two periods :

(a) Prior to the arrival of flood water when they formed mat like growth on soil surface which might be due to relative abundance of soil moisture and (b) following transplanting (mid July to August) when dense algal blooms were found to develop. This seemed to be the consequence of fertilizer application and ploughing and also high light availability (Saito and Watanabe, 1978). Gradual decrease of algal vegetation during latter part of flooding (October-November)seemed to be due to the consumption by grazers (Kurasawa, 1956) and reduced light under the rice canopy (Ichimura, 1954 and Kurasawa, 1956). During this period *Gloeotrichia* was found to be attached to the stem and the blue-green algal vegetation as a whole, was found to cover 5-8% of water surface. Species of *Gloeotrichia*, *Rivularia* and *Anabaena* were found to be predominant during the months of July and August when the water depth, temperature, conductivity, dissolved O_2, total alkalinity and pH were high. Species of *Calothrix* and *Aulosira* were found to be occasional (being partly attached to the stem) in the month of September when the water temperature and pH were high but water depth, total alkalinity, dissolved O_2 and free CO_2 were low. Epiphytic algae (especially *Gloeotrichia*) were found to grow upto 0.7—1.0 meter depth. This was partly possible because the water was more transparent.

In addition to blue-green algae some of the eukaryotic algae such as *Oedogonium* and *Cosmarium* were found to be frequent (Table 4) during the period when water depth, temperature (Table 1), conductivity, total alkalinity, dissolved O_2, free CO_2 and pH were high (Table 2). In contrast, *Fragilaria* and *Navicula* were found to be frequent and occasional respectively when the water depth, free CO_2 and dissolved O_2 were low but pH, total alkalinity and conductivity were high. Use of nitrogenous fertilizers seemed to have enhanced the growth of eukaryotic algae (Bunt 1961, Ciferri 1960, 1963). More or less similar result was found in this experiment (Table 3).

C. Correlation study.

Most of the algal genera showed no significant relationship with total N and P content of the soils (Table 5). Only *Nostoc*, *Spirogyra* and *Navicula* showed significant relationship with soil N and those of *Gloeotrichia* and *Pinnularia* with P at 10% level grown during flooded period. Algal population was influenced by the chemistry of water, though not significantly. In most of the cases pH of water significantly influenced the growth of *Coleochaete*, *Oedogonium* and *Cosmarium* in the rice field. The genus *Calothrix* was stimulated by concentration of O_2 and total alkalinity of the water. Free CO_2 affected the growth of *Pinnularia* only.

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