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N_2-FIXING BLUE-GREEN ALGAE IN RICE FIELDS AND THEIR RELATIONSHIP WITH SOIL FERTILITY

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Key words : N_2-fixing BGA, Rice field, Soil fertility, Correlation coefficient.

Abstract

Quantitative distribution of total algae and nitrogen fixing blue-green algae (NFBGA), and the causes of their variation in a wide range of 58 rice field soils were assessed. Total number of algae varied from 0.09×10^6 to 3.49×10^6 and that of NFBGA between 0.55×10^4 and 18.40×10^4 with a mean of 1.36×10^6 and 3.22×10^4 g^{-1} soil respectively. Moreover, the population of NFBGA accounted about 0.36 to 16.94% of the total algae with an average of 3.55%.

Significant coefficient of single correlation suggested that total and NFBGA varied directly with soil pH. However, NFBGA varied negatively with total N ($P<0.01$) and positively with available P ($P<o.5$) content of the soils. Multiple correlation revealed that effect of pH together with organic carbon, total N and available P is significantly better in the variation of total and NFBGA in soil than their individual contributions. This suggests that variation in algal population particularly in NFBGA in soil is a joint contribution of pH, organic carbon, total N and available N and P of the soils.

Introduction

Very recently, the use of N_2-fixing blue-green algae as biofertilizer in modern intensive rice farming has received tremendous importance because of the high production cost of chemical N-fertilizers. Moreover, the algal biomass also contributes significantly to the improvement of soil fertility. It has been reported that under natural conditions, the growth of BGA is limited by environmental factors (Roger and Reynaud 1979). The growth of N_2-fixing BGA is stimulated favourably in soil having high pH (Pandey 1965) and available P (Araragi *et al.* 1978). Rinaudo *et al.* (1971) reported the selective action and inhibitory effect of N-fertilizers on growth of N_2-fixing BGA.

Since majority of the NFBGA are soil borne, it would be a logical approach to stimulate their proliferation by generating conducieve soil condition for profitable rice cultivation. Thus, attempts have been made to assess the quantitative status of soil algae particularly the N_2-fixing BGA and the contri-

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bution of soil fertility factors in their variation in a wide range of rice soils of Bangladesh.

Materials and Methods

Fifty eight samples of surface soil (0-5 cm) were collected from rice fields of 27 districts of Bangladesh. Each composite sample of 5 sub-samples was air-dried, ground and passed through 10 mesh sieve for chemical analysis.

Quantification of algae : The quantitative enumeration of algae including nitrogen fixing blue-green algae was done by most probable number (MPN) method (FAO 1967) using probability table (Alexander 1965). Fogg's liquid medium (1949) with and without nitrogen was used for the enumeration of total and nitrogen-fixing algae respectively.

Analytical Techniques : Determinations were made of soil pH by Cornning pH meter (soil : water ratio being 1: 2.5), organic carbon by wet oxidation method (Walkley and Black 1934), total and 2M KCl extractable N by micro Kjeldahl procedure (Jackson 1958). 0.5M acetic acid extractable P was estimated spectrophotometrically (Williams and Stewart 1941).

Results and Discussion

Variation in algal population in rice fields have been examined and the results thus obtained are presented in Tables 1-2.

Nutritional status of the soils : Table 1 shows that soils were almost neutral in acidity and decidedly very low in organic carbon. Total and available N status of the soils were very low and status of available P was also slightly low to very low suggesting that the soils were generally low in fertility.

Algal status of the soils : Number of algae varied notably from soil to soil. Total number of algae ranged from 0.09×10^6 (Khagrachuri) to 3.49×10^6 g^{-1} soil (Noakhali) with an overall mean of 1.36×10^6 g^{-1} soil. Number of nitrogen fixing blue-green algae (NFBGA) varied between 0.55×10^4 and 18.40×10^4 g^{-1} soil in Khagrachuri district and Brahmanbaria Sadar soils respectively with an average of 3.22×10^4 g^{-1} soil. Per cent distribution of N_2-fixing BGA accounted about 0.36 to 16.94% of the total algal population in Meherpur and Halishahar (Chittagong) soils, respectively, with a mean of 3.55%.

Assessment of algal variation : Variation in total and NFBGA (*Cylindrospermum muscicola, Anabaenopsis tanganyikae, Nostoc* (6 spp.), *Anabaena* (5

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Table 1. Soil properties and population of total and NFBGA in rice field.

District	pH	Org. C	Total N	Available N	Available P	No. of algae (g^{-1} soil) Total	No. of algae (g^{-1} soil) NFBGA	NFBGA
		%	%	mg $100g^{-1}$	$\mu g\ g^{-1}$	$x10^6$	$x10^4$	%
Rajbari	7.7	0.28	0.11	5.1	11.7	2.98	4.22	1.34
Narshingdi	7.1	0.85	0.12	8.4	11.4	1.02	1.86	1.82
Kishoreganj	5.3	0.26	0.07	5.6	14.2	0.49	0.98	2.00
Tangail	7.1	0.68	0.18	3.2	9.9	1.06	1.98	1.82
Mymensingh	7.0	0.38	0.11	4.2	9.8	0.89	1.63	1.82
Dhaka	7.1	1.41	0.18	4.2	13.7	0.92	1.65	1.80
Narayanganj	7.0	2.44	0.22	3.5	21.5	0.85	1.50	1.76
Madaripur	7.4	0.45	0.14	6.7	12.3	1.53	3.90	2.44
Shariatpur	7.4	0.46	0.15	4.1	13.5	1.70	3.67	2.13
Gopalganj	7.6	0.32	0.13	3.2	12.3	2.40	5.55	2.31
Faridpur	7.5	0.50	0.16	4.6	11.0	1.60	3.56	2.16
Brahmanbaria	6.8	0.44	0.10	1.4	18.5	1.40	18.40	13.14
Noakhali	6.9	0.89	0.09	3.5	16.3	3.49	3.33	0.95
Cox's bazar	6.7	0.22	0.11	1.4	10.2	0.11	1.12	10.18
Chittagong	6.8	0.48	0.07	1.8	15.0	0.35	5.92	16.94
Rangamati	7.2	0.22	0.06	3.5	17.5	0.13	1.30	10.00
Khagrachuri	6.2	0.74	0.13	9.8	10.1	0.09	0.55	6.11
Moulavibazar	7.2	0.37	0.12	3.5	15.0	1.20	2.50	2.07
Sylhet	5.7	0.58	0.20	7.4	12.3	0.76	1.35	1.75
Jessore	7.3	0.95	0.14	5.6	16.5	1.45	2.80	1.93
Jhenaida	7.3	0.11	0.05	4.9	12.7	1.23	2.60	2.11
Narail	7.3	0.73	0.11	6.7	14.2	1.34	2.76	2.02
Kushtia	7.8	1.36	0.15	5.6	20.6	3.14	5.00	1.59
Meherpur	7.5	0.41	0.21	9.1	18.4	1.92	0.70	0.36
Patuakhali	6.5	1.08	0.10	6.3	18.4	0.60	1.04	1.73
Pabna	7.8	0.19	0.06	5.6	15.3	3.42	6.14	1.79
Rangpur	5.7	0.79	0.08	8.4	14.6	0.57	1.00	1.75
LSD ($P<0.05$)	0.11	0.08	0.02	0.31	0.73			

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Table 2. Single, partial and multiple correlations of total algae and nitrogen-fixing blue-green algae with soil properties.

Independant variable	Dependant variable	
	No. of total algae	No. of NFBGA
X_1	0.600 ***	0.381*
X_2	—0.130ns	—0.159ns
X_3	—0.086ns	—0.427 **
X_4	0.103ns	—0.180ns
X_5	0.132ns	0.380 *
X_1X_2	0.601 ***	0.303ns
X_1X_3	0.609 ***	0.359 *
X_1X_4	0.642 ***	0.308 *
X_1X_5	0.609 ***	0.381 *
X_2X_3	0.136ns	0.232ns
X_2X_4	0.174ns	0.230ns
X_2X_5	0.223ns	0.372 *
X_3X_4	0.131ns	0.300ns
X_3X_5	0.155ns	0.340 *
X_4X_5	0.165ns	0.331 *
$X_1X_2X_4$	0.643 ***	0.321ns
$X_1X_2X_5$	0.610 ***	0.434 **
$X_1X_3X_4$	0.648 ***	0.386 *
$X_1X_3X_5$	0.616 ***	0.439 **
$X_1X_4X_5$	0.644 ***	0.404 *
$X_2X_3X_4$	0.180ns	0.297ns
$X_2X_3X_5$	0.225ns	0.390 *
$X_2X_4X_5$	0.253ns	0.409*
$X_1X_2X_3X_4$	0.854 ***	0.959 ***
$X_1X_2X_3X_5$	0.896 ***	0.848 ***

X_1, X_2, X_3, X_4, and X_5 represent pH, organic C, total N, available N and available P respectively

ns=not significant.

*, $P<0.05$; **, $P<0.01$; ***, $P<0.001$.

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spp.), *Microchaete tenera*, *Nodularia* sp., *Aulosira* (5 spp.), *Scytonema* (5 spp.), *Tolypothrix* (3 spp.), *Calothrix* (7 spp.), *Hapalosiphon* (3 spp.), *Westiellopsis prolifica*, *Fischerella* (2 spp.) and *Stigonema* sp.) in soil was assessed (Tables 2 and 3).

Table 3. Samples positive for blue-green algae in rice fields.

Blue-green algae	Samples positive for BGA
Microcystis aeruginosa	2
Chroococcus spp. (4)	6
Gloeocapsa spp. (4)	8
Gloeothece sp.	1
Aphanocapsa spp. (3)	4
Aphanothece sp.	4
Synechocystis spp. (2)	5
Synechococcus aeruginosus	1
Myxosarcina sp.	1
Oscillatoria spp. (12)	27
Phormidium spp. (2)	19
Lyngbya spp. (5)	16
Schizothrix lamyi	2
Microcoleus sp.	3
Cylindrospermum muscicola	2
Nostoc spp. (6)	21
Anabaena spp. (5)	8
Microchaete tenera	4
Pseudoanabaena sp.	4
Nodularia sp.	1
Raphidiopsis indica	1
Aulosira spp. (5)	7
Plectonema sp.	16
Scytonema spp. (5)	9
Tolypothrix spp. (3)	7
Calothrix spp. (7)	18
Hapalosiphon spp. (3)	12
Mastigocoleus testarum (?)	5
Westiellopsis prolifica	5
Fischerella spp. (2)	20
Stigonema sp.	2

Figures in the parenthesis indicate number of species under each genus.

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Single correlation study suggests that soil pH has got impact on both total and NFBGA significant at 0.1 and 5% level respectively (Table 2). This suggests that higher concentration of H^+ ion affects the growth and development of algae grown in soil. Pandey (1965) reported that growth of NFBGA is favoured by higher pH values and under natural conditions BGA grow preferentially in environments that are neutral to alkaline in reaction (Roger and Reynaud 1978, Aziz *et al.* 1991). Single correlation coefficient further shows that population of NFBGA bears an inverse significant relationship ($P<0.01$) with total N content of the soil. A non-significant relationship of NFBGA with available N was also observed which is quite obvious. The coefficient of correlation between number of NFBGA and total N was higher (r=0.427**) in comparison to that of between total algal population and total N (r=0.086 ns) indicating the fact that NFBGA is more sensitive to N content of the soils than all other algal population (Table 2). This further suggests that growth of NFBGA is greatly favoured in soil deficient in nitrogen. The inhibitory effect of added nitrogen on N_2-fixing BGA has also been demonstrated by Rinaudo *et al.* (1971).

Though not total algae but N_2-fixing BGA bear a significant relationship ($P<0.05$) with available P, the growth of algae in paddy soil could be promoted through phosphorus supply (Srinivasan 1978). Okuda and Yamaguchi (1952) noted that growth of BGA in moist soil was closely related to the available phosphorus content of soil and was poor at 0 to 5 $\mu g\ g^{-1}$, but vigorous at above 6 $\mu g\ g^{-1}$ soil. Both total and NFBGA population showed negative correlation with organic carbon, total and available N content of the soil though not significantly.

Coefficients of multiple correlation suggest that BGA including NFBGA are undoubtedly regulated by soil fertility factors. The joint contribution of pH and other factors is significantly better than their individual contributions. This suggests the partial contribution of all the variables. The significant coefficient of multiple correlation obtained from three and four factor interactions indicates that variation of both total and NFBGA population in soil is not a function of single soil property rather of an interaction and joint contribution of all the variables included in the study.

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