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Increase in Macro-nutrients of Soil by the Application of Blue Green Algae in Rice Production

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Abstract: Four treatments were considered viz., No-control, UN-chemical fertilizer applied 24 hours before a transplantation, AN- algal mixture applied seven days after transplantation and UN+ AN- fertilizer and algal inoculum used together. Highest amount of available nitrogen contents of soil in third crop was obtained suggesting positive residual effect of algalization. As expected the amount of organic matter of the soil was found to be less in third crop than the second crop. The magnitude of difference between a set of treatments due to algal inoculation was highest in the third season suggesting that the benefit occurred over the year.

Key words: Residual effect, rice varieties, blue-green algae

Introduction

Rice, being one of the most remarkable cultivated crops is able to grow in a wide range of climate, soil and water conditions. It grows from wet tropical to semi-arid and to warm temperate climate, in heavy clays or poorly sandy soils, on dry land or in swampland. But for the increased production of grains per hectare, soil fertility is the most important factor. This fertility mainly depends upon three major nutrient elements namely nitrogen, phosphorus and potassium. Among all the major elements nitrogen compound is one of the key element for the fertility of soil so to say the increased crop production. The blue-green algae not only enrich the soil with nitrogen but also secrete some growth promoting substances for rich plants (Subrahmanyan *et al.*, 1965c) and thus there is greater need for harvesting the indigenous nitrogen fixing blue-green algae under the local conditions. Moreover, the position of commercial fertilizer nitrogen in the less developed countries shows an enormous gap between production and consumption. Any saving in the consumption and any alternative source of chemical nitrogen fertilizer without affecting the productivity will, therefore, be not only a great economic advantage but also a strategic necessity (Venkataraman, 1977; Bhuiya *et al.*, 1984). The most promising way is to trap the atmospheric nitrogen and the biological potential of plants (Venkataraman, 1977) and for paddy rice, blue-green algae is one of the important biological sources of combine nitrogen. The present day global interest in biological nitrogen fixation is a direct consequence of this input constraint. It is observed that blue-green algae can fix 25.30 kg nitrogen/ ha per cropping season and its use in conjunction with artificial fertilizer can reduce up to 30% of the latter's use which increase the yield by as much as 20% (Bhuiya *et al.*, 1984).

Blue-green algae are common in flooded rice paddy soils, particularly in the tropics. These nitrogen-fixing blue-green algae grow most abundantly in tropical and subtropical regions and are less common in temperate and subtemperate regions (Watanabe and Yamamoto, 1971). A long-term field experiment was laid out in the present report to examine the effect of algalization on the high yielding, fertilizer-responsive rice varieties as well as on the soil properties.

Materials and Methods

The trial conducted in a triple-crop land involving three successive rice crops, viz. June-September, October-January and February-April. Transplantation was done on June, October and February, respectively for each of the three crops with a spacing of 15 X 20 cm^2 for BR-3 and 15 X 10 cm^2 for BR-7. During the present investigation two high yielding varieties, BR-3 (BRRI-BIPLAB) and BR-7 (BRRI-BALAM) were used as plant material of rice. Seeds were obtained from the Bangladesh Rice Research Institute (BRRI), Joydebpur, Dhaka, Bangladesh and the research was carried out in the laboratory of Microbiology and Biochemistry, Bangladesh Jute Research Institute and Department of Botany, University of Dhaka, Bangladesh during one year. The soil algal culture containing a mixture of five BGA spp. (*Anabaena variabilis*, *Aulosira fertilissima*, *Scytonema* sp., *Calothrix javanica*, and *Westiellopsis prolifica*) were used as a substitute for nitrogen fertilizer i.e. urea, was collected from a rice field in Tangail, Bangladesh and were thoroughly mixed with two litters of water and sprinkled uniformly over the respective treatment plots at a rate of one Kg (dry weight) per ha. during each season. Dilute solution of NaOH was added to the soil to raise the pH to about 7.5-8.0 for promoting the optimum growth of BGA used as biofertilizer. NPK was applied in the ratio of 0.60 : 0.48 : 0.36 g/pot calculated on the basis of recommended dose of NPK 45: 36: 27 Kg/ha. The entire amount of Triple Super-Phosphate and Muriate of potash along with 50% of urea was applied 24 h prior to transplantation. The other half of urea was applied before panicle initiation. To minimize the loss of nitrogen through volatilization, urea was always applied below the sub-surface soil. After seven days of transplantation, 2.0 g of algal inoculum (a mixture of *Anabaena variabilis*, *Aulosira fertilissima*, *Scytonema* sp., *Calothrix javanica* and *Westiellopsis prolifica*) was inoculated in dry state as a substitute for urea. The different treatment combinations were designed as follows: No = Control, UN = where source of nitrogenous fertilizer was chemical fertilizer, AN = where source of nitrogenous fertilizer was algal inoculum, UN + AN = where source of nitrogenous fertilizer, urea and algal inoculum together. There were four replications for each treatment of the two cultivars of rice BR-3 and BR-7. These replicates were arranged in a completely randomized block design. Randomization was achieved following a standard random permutation table with 1-20 integers. The seeds of BR-3 were germinated on the moist filter paper in the laboratory in dark in Boro season for first crop. For second crop the seeds of BR-3 were sown in t. Aman season. The germinated seeds were spot sown in the seedbed, which was provided with sufficient manure and water supply. Similarly the seeds of BR-7 were also sown in

t. Aman season. For each variety two healthy seedlings (28 days old) were transplanted into the soil which had been made puddle before transplantation. Various cultural operations were made from time to time such as weeding and water supply, etc.

For the purpose of mechanical and chemical analysis, the soil was collected at maximum tillering, at flowering and at the time of harvesting of the two cultivars, viz. BR-3 (Boro and transplant Aman season) and BR-7 (transplant Aman season). Initial analysis of the soil was also conducted and collected soil samples were air dried, ground and passed through 2-mm sieve for mechanical analysis. For the determination of pH, moisture content and available nitrogen, some soil was collected at the above mentioned three stages of plant growth and also before the addition of fertilizer and blue-green algae. Physical analysis of soil were done by mechanical means by modified hydrometer method originally proposed by Bouyoucos (1928) and textural class was determined from the triangular coordinates as devised by US Department of Agriculture (1951). The percentage of moisture content of soil was determined by the following method: (a) Known amount of soil was dried in an electric oven at 105 °C for 24 h (b) the final weight of the soil was recorded and © the loss of moisture was determined by the initial and final weight. The pH of the soil was determined electrochemically by a corning glass electrode pH meter (Model-7). The ratio of soil to water was 1:2.5 as described by Jackson (1962). The organic carbon was determined volumetrically by wet-oxidation with 1N $K_2Cr_2O_7$ and concentrated H_2SO_4 mixture and rapid titration of the residual $K_2Cr_2O_7$ with 1N Fe_2SO_4 solution, following Walkley and Black's method (1934) as described by Piper (1966). Organic matter content of the soil was determined by multiplying the organic carbon with the conversion factor 1.724 (Piper, 1966). The total nitrogen content of the soil was determined by digesting the sample with concentrated H_2SO_4 together with digesting mixture in Kjeldahls flask and distilling the contents in a microkjeldahls distillation apparatus with 40% NaOH solution. The ammonia evolved was observed in 4.0% boric acid with mixed indicator and the excess of the acid was back titrated with a standard N/56 H_2SO_4. Available nitrogen was determined from an aliquot of 2N KCl leachate following micro Kjeldahl's distillation method as out lined by Jackson (1962).

Results

In an effort to study the residual effect on blue-green algae on the soil fertility, initially some physical and chemical properties of soil were conducted which are given in Table 1, where no significant changes were observed in pH and moisture (%) of soil before and after application of blue-green algae.

Nitrogen content of soil: The total nitrogen content of rice growing soil which was treated with either blue-green algal inoculum alone or in combination with urea are presented in Fig. 1.

BR-3: At maximum tillering stage (Boro season), the highest value of 0.14% nitrogen content was obtained from the soil treated with chemical fertilizer only and the lowest value of 0.09% was in control soils. In this variety in t. Aman season (third crop) the highest percentage of nitrogen content i.e. 0.141% was recorded in the treatments where blue-green algal inoculum in combination with fertilizer (urea) was added. The lowest value of 0.09% (which was exactly same as in Boro season) was obtained in the control treatments. At flowering stage, the highest value of nitrogen content was 0.102% and 0.138% in Boro and t. Aman season, respectively in the soil treated with blue-green algal inoculum and fertilizer together. The second highest percentage of nitrogen, 0.125% and 0.137% were recorded, in the soil of Boro and t. Aman seasons, respectively where only algal inoculum was applied instead of fertilizer (Fig. 1B). The percentage recorded in t. Aman season (third crop) was found to be much higher than that (0.08%) in the soil where only urea fertilizer was applied. The lowest percentage of nitrogen e.g. 0.055% and 0.041% were recorded in Boro and t. Aman seasons, respectively in control soil. At harvesting stage of Boro season as well the maximum nitrogen content (0.125%) was obtained from the soil treated with algal inoculum and fertilizer together. As expected the nitrogen content was found to be higher e.g. 1.48% in the same soil in t. Aman season where the value had been 1.125% in Boro season. The second highest value 0.145% was obtained from the soil where only algal inoculum was used. This value was found to be more than double than that (0.062%) in only fertilizer treated soil and also higher than that (0.110%) in Boro season.

BR-7: At maximum tillering stage, BR-7 variety (t. Aman) showed the highest value of 0.13% nitrogen in the treatments where algal mixture and fertilizer together were added. As in BR-3 (Boro), here also the lowest nitrogen value (0.067%) was obtained in control treatments. As expected this variety showed the highest percent of nitrogen (0.125%) in the soil treated with both algal inoculum and fertilizer at flowering stage. The second and third highest values of nitrogen content of 0.11% and 0.6% were recorded in the soils where only algal inoculum and only fertilizer respectively were used.

Available nitrogen content of soil: Available nitrogen content of soil as influenced by blue-green algae and fertilizer measured at three different growth stages, are presented in Fig. 2.

BR-3: At tillering stage of Boro season the highest value (60.48 ppm) was obtained in fertilizer treated soil and the lowest value (34.48 ppm) was found in control treatments. Although the available nitrogen was found to be lower (50.40 ppm) in algae treated soil, but it was much higher than that in control (Fig. 2A). In t. Aman season the highest value (75.70 ppm) was recorded in the soils treated with algal inoculum and fertilizer together; the lowest value (40.40 ppm) was found in the soils of control treatments. The second highest available nitrogen content (59.00 ppm) was more in algae treated soils than that (48.90 ppm) in only fertilizer treated soil. At flowering stage, the highest and lowest values of 61.04 ppm and 25.20 ppm were found in algae treated and control soil, respectively in Boro season. In t. Aman season as well the highest value (44.26 ppm) and lowest value (20.12 ppm) were obtained in algae treated and control soils, respectively. At harvesting stage of measurement (Boro season) the highest value (60.26 ppm) was recorded from soil, treated with algal mixture and fertilizer together. In t. Aman season as well the highest values of 64.26 ppm was found in the soil treated with algal inoculum and fertilizer together.

BR-7: At maximum tillering stage the highest value of 61.74 ppm was found in the soil where algal mixture and fertilizer were used together. The second highest value, 44.10 ppm, was obtained in the algae treated soils. At the same stage

Table 1: Some physical and chemical properties of soil

Mechanical composition					Varieties			
					BR-3		BR-7	
Sand (%)	Silt (%)	Clay (%)	Textural class	Treatment	pH	Moisture (%)	pH	Moisture (%)
				No	5.20	36.67	5.00	35.20
50	30	20	Loam	UN	5.00	36.00	5.30	35.00
				AN	5.30	34.00	5.50	32.00
				UN+ AN	5.40	34.29	5.60	33.20

No= Control, UN = Chemical fertilizer, AN = Algal mixture, UN + AN = Fertilizer and algal inoculum

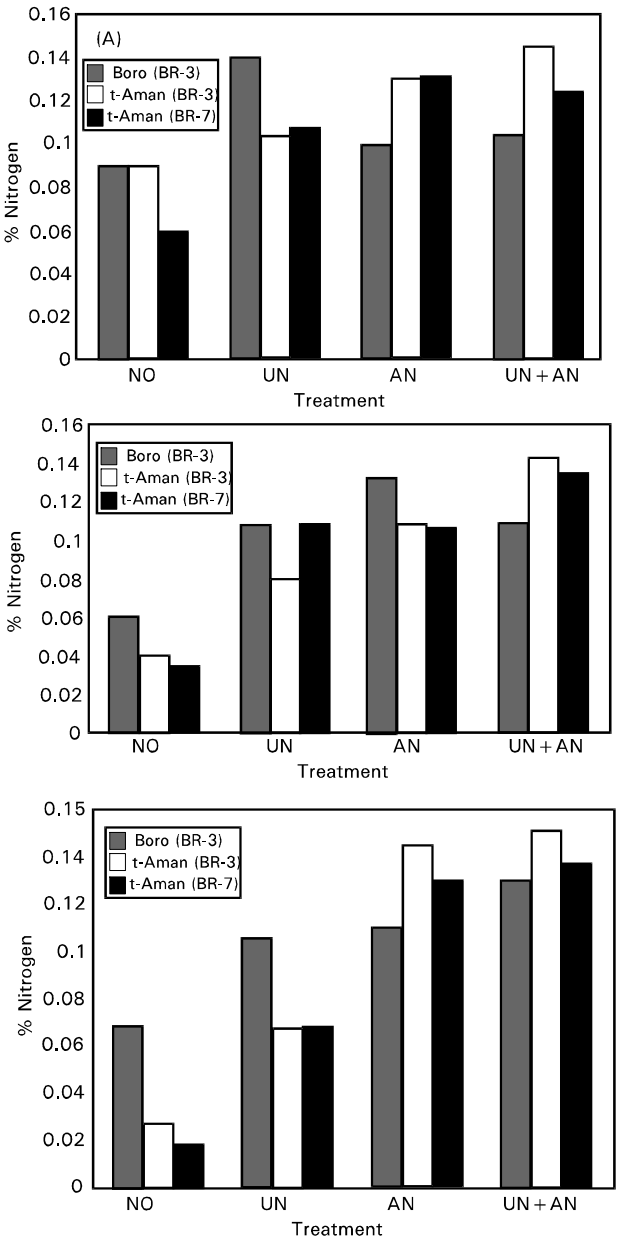

Fig. 1: Nitrogen content of soil - (A) at maximum tillering stage, (B) at flowering stage and ©at harvesting stage- of growth as influenced by the application of blue green algae with or without urea.

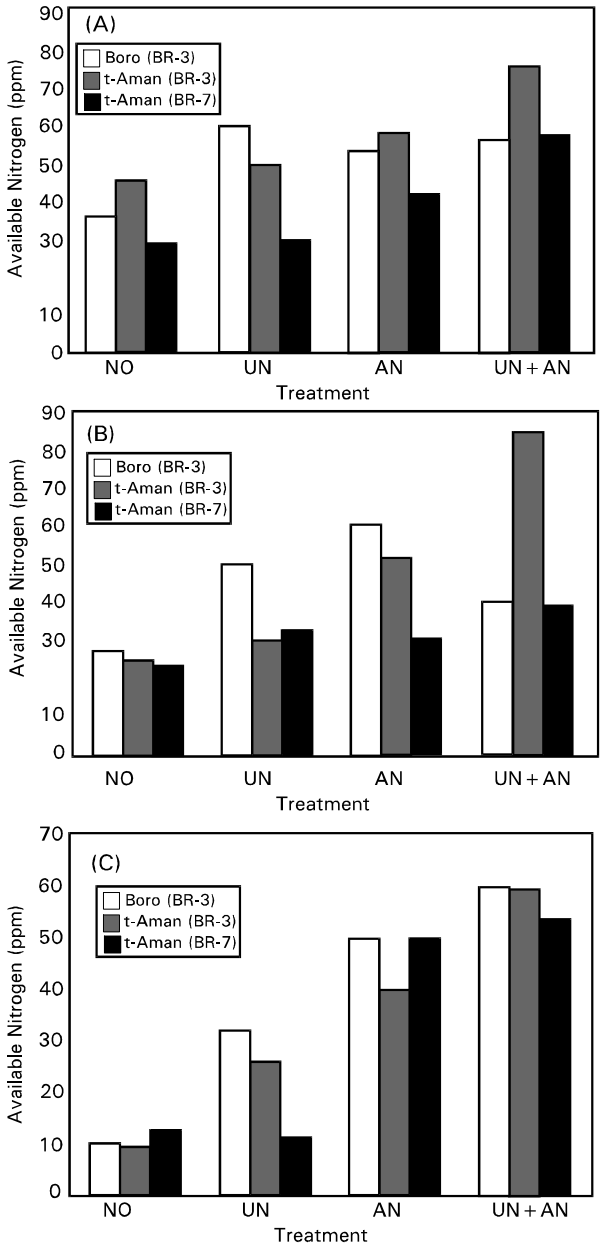

Fig. 2: Available nitrogen content of soil, (A) at maximum tillering stage, (B) at flowering stage and ©at harvesting stage of growth as influenced by the application of blue green algae with or without urea.

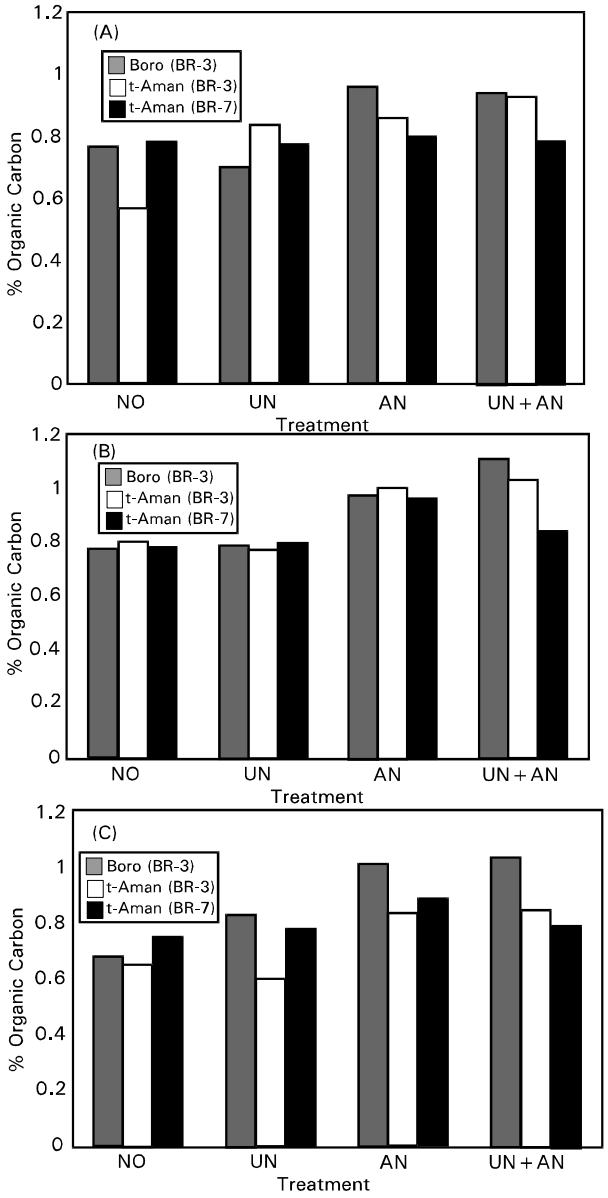

Fig. 3: Organic carbon content of soil (A) at maximum tillering stage, (B) at flowering stage and ©at harvesting stage of growth as influenced by the application of blue green algae with or without urea.

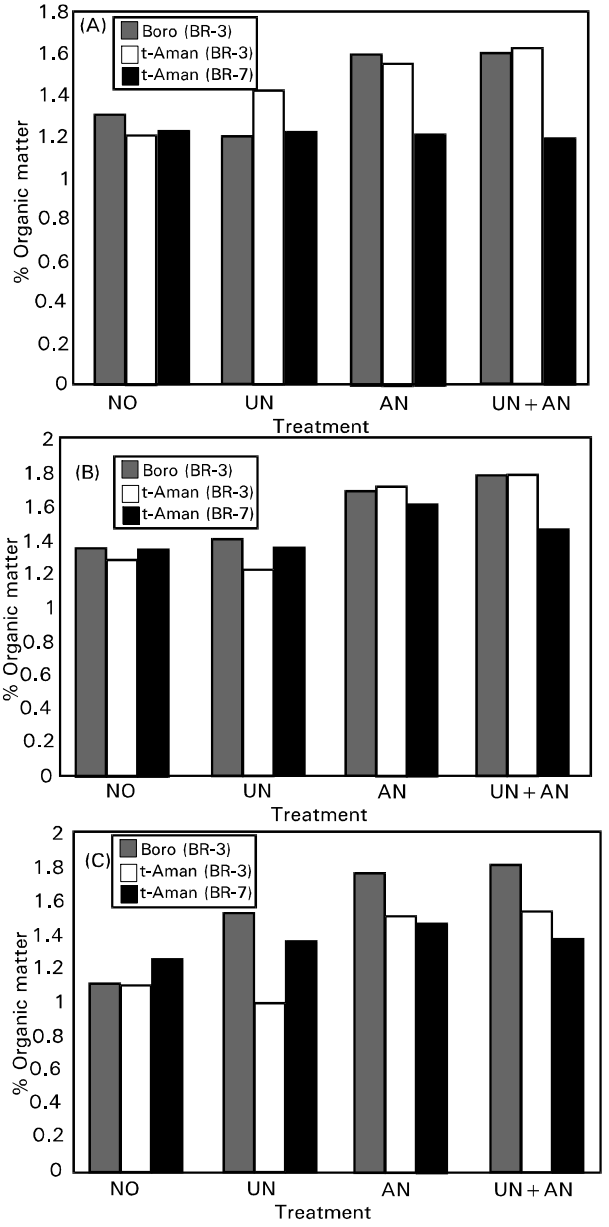

Fig. 4: Organic matter content of soil (A) at maximum tillering stage, (B) at flowering stage and ©at harvesting stage, as influenced by the application of blue-green algae with or without urea.

fertilizer treated soils produced the 3rd highest value of available nitrogen (32.64 ppm) which was very close to that (30.40 pm) in control treatment. At the flowering stage nitrogen content decreased in all treatments. The values were found to be 42.84 ppm in treatment of dual combinations. The second highest value (30.24 ppm) was obtained in only fertilizer treated soils and 27.72 ppm of available nitrogen was found in algae treated soil. The lowest value (21.42 ppm) was found to be in the soil of control treatments. At harvesting stage, available nitrogen content was found to be 59.30 ppm, 47.88 ppm and 13.86 ppm in the soils treated with both algal inoculum and fertilizer, only with algal inoculum and only chemical fertilizer, respectively.

Incidentally here the lowest value, 13.86 ppm was also found in control soils.

Organic carbon contents of soil: The organic carbon of soil as influenced by blue-green algae and fertilizer, measured at three different growth stages, are presented in Fig. 3.

BR-3: The highest carbon content of 0.95% was obtained in only algae treated soil at tillering stage of Boro season, whereas the lowest value (0.70%) was in only fertilizer treated soil. At flowering and harvesting stages of growth, the highest amount

of organic carbon was recorded in the soils treated with both algal inoculum and fertilizer. However, organic carbon was found to be higher in only algae treated soil over that of only fertilizer treated soils at all three growth stages. In t. Aman season, the results were found to be different showing a gradual decrease in organic carbon from maximum tillering stage to harvesting stage. However, the rate of decrease was found to be less in soil treated with only algal inoculum.

BR-7: Maximum amount of organic carbon was found to be in the soil collected at flowering stage in all the treatments, the highest amount being in only algae treated soil. These values were also found to decrease in the soils collected at harvesting stage of growth (Fig. 3C).

Organic matter content of soil: The organic matter content of soil as influenced by blue-green algae and fertilizer measured at three different growth stages is presented in Fig. 4.

BR-3: At tillering stage of Boro season the highest percent (1.63%) of organic matter was obtained in only algae treated soil. The second and third (1.59% and 1.25%) highest values were obtained in the treatments of dual combinations and control, respectively. But at flowering and harvesting stages, the highest organic matter was found in the soil samples treated with both algal inoculum and fertilizer. The next highest amount was much higher (1.75%) than that (1.41%) in only fertilizer treated soil. In t. Aman season, the highest and second highest values of 1.61% and 1.53% were obtained in the soil treated with both fertilizer and blue-green algae, and only blue-green algae respectively at maximum tillering stage. Although organic matter was found to be more in the soil at flowering stage (except in only fertilizer treated soil) (Fig. 4B), these values came down at harvesting stage following each treatment.

BR-7: The amount of organic matter was found to be highest at flowering stage following each treatment in this variety as well (Fig. 4B). At harvesting stage, the amount of organic matter was found to be less in the soil following each treatment. Here highest amount of organic matter was recorded from only algae treated soil at three stages of plant growth (Fig. 4C).

Discussion

The results of nitrogen content of rice growing soil during different stages of growth of rice plants are shown in Fig. 1 where at harvesting stage of measurement, the variation in nitrogen content of soil were significant at 1% level in t. Aman season of BR-3 and non significant in BR-3 (Boro) and BR-7 (t. Aman). It is seen that total nitrogen content was more in the soil of only algae treated plot in both the varieties in both seasons in comparison with non algae treated soil. However, maximum nitrogen was recorded in soil receiving both algal and fertilizer nitrogen. Alimagno and Yoshida (1975) also reported that total nitrogen content of soil increased when inoculated with nitrogen fixing blue-green algae. Similar results were recorded by Singh (1961) and Subrahmanyan *et al.* (1965 a & b). The results presented in Fig. 2 show that in BR-3, although initially the available nitrogen content was higher in only fertilizer treated soil at maximum tillering stage of Boro season but finally the same was more in algae treated soil. This might be due to increase in supply of available nitrogen through biological nitrogen fixation and decomposition. The positive effect of algalization is quite evident in Boro and t. Aman seasons (Fig. 2 A & B) where available nitrogen was higher in algae treated soil than those in only fertilizer treated and control soil. In BR-7 as well available nitrogen was much higher (about four time more) in algae treated soil than only fertilizer and control soil. Here the highest amount of available nitrogen was obtained in the soil treated with both algal inoculum and fertilizer together at all the three stages of measurement. It seems that algae either alone or in combination with urea fertilizer produced better impact on available nitrogen. Yoshida and Ancajas (1973) reported that because of the atmospheric nitrogen fixation through microorganisms, nitrogen is continuously available to rice in flooded soils.

From a comparison of the data shown in Fig. 3, it is evident that concentration of organic carbon was more in the soil treated with only algae inoculum than only fertilizer and treatment of dual combinations especially at flowering stage in both the varieties (BR-3 and BR-7). This might be due to the active growth of algal mass at the tillering stage. According to Sankaram (1977), blue-green algae, in addition to nitrogen contribution, help in the accumulation of organic carbon in soil. The gradual decrease in organic carbon content at harvesting stage (Fig. 3C) might be due to the depletion of organic carbon. This is quite possible because microbes, responsible for mineralization of algal mass immediately require carbon as source of energy to synthesize their body material. Analysis of soil from the various treatments at different growth stages of rice plants showed (Fig. 4) that only algae inoculated soil had higher organic matter content as compared with only fertilizer treated and control soil at three stages of development of both the varieties. These clearly indicate the positive effect of algalization. Jha *et al.* (1965) and Watanabe *et al.* (1977) also showed increase in organic matter in the soil following algal inoculation. As regards the residual effect, the amount of organic matter was found to be less in the soil of t. Aman season than that of Boro season. This might be the result of mineralization of algal mass in the second season. According to Aiyer *et al.* (1972) this is because the organic matter are rapidly lost from soil owing to the activities of various agencies under tropical conditions.

From the present study, it may be stated that there is great potential of algal inoculation in the nitrogen enrichment of paddy soil. Blue-green algae not only provide nitrogen for rice plant but also thrive well with the crop without competing either for nutrients or light. In addition, as a source of manure, blue-green algae are available throughout the year.

References

Aiyer, R. S., S. Salahudeen and G. S. Venkataraman, 1972. Long-term algalization field trial with high-yielding varieties of rice (*Oryza sativa* L.). Indian J. Agric., 42: 380-383.

Alimagno, B. V. and T. Yoshida, 1975. Growth and yield of rice in Maahas soil inoculated with nitrogen fixing blue-green algae. Philipp. Agric., 59: 80-90.

Bouyoucos, G. L., 1928. The hydrometer is making a very detailed analysis of soils. Soil Sci., 26: 223-238.

Bhuiya, Z. H., A. K. M. N. Islam, M. A. Hashem, Z. N. T. Begum and M. M. Rahman, 1984. Effect of blue-green algae as biofertilizer on rice. Bangla. J. Agric., 9: 47-51.

Jackson, M. L., 1962. Nitrogen determination from soils and plant tissues. In: Soil Chemical Analysis. Constable and Company, Ltd., W. C. London, pp: 183-204.

Jha, K. K., M. A. Ali, R. Singh and P. B. Bhattacharya, 1965. Increasing rice production through the inoculation of *Tolypothrix tenuis* a nitrogen fixing blue-green algae. Indian Soc. Soil Sci., 13: 161-166.

Piper, C. S., 1966. Soil and plant analysis. Hans publishers. Bombay, pp: 59-74.

Subrahmanyan, R., G. B. Manna and S. Patnaik, 1965a. Preliminary observation on the interaction of different rice soil types to inoculation of blue-green algae in relation to rice culture. Proc. Indian Acad. Sci., 62B: 171-175.

Subrahmanyan, R., L. L. Relwani and G. B. Manna, 1965b. Nitrogen enrichment of rice soil by blue-green algae and its effect on the yield of paddy. In symposium on land fertility improvement by blue-green algae. Proc. Natl. Acad. Sci., India, 35A: 382-386.

Subrahmanyan, R., L. L. Relwani and G. B. Manna, 1965c. Fertility build-up of rice field soils by blue-green algae. Proc. Indian Acad. Sci., 60B: 252-272.

Sankaram, A., 1971. Work done on blue-green algae in relation to agriculture. ICAR, New Delhi. Bull. No. 27: 27-28.

Singh, R. N., 1961. Role of blue-green algae in the nitrogen economy of Indian agriculture. ICAR, New Delhi., pp: 1-175.

USDA, 1951. Soil survey manual by soil survey staff, Bureau of plant industry, Soils and Agricultural Engineering.

Venkataraman, G. S., 1977. Algal biofertilizer for rice production. Shiv Narayan Printer. 6, community center, east of Kailash, New Delhi, pp: 3-4.

Walkley, S. A. and I. A. Black, 1934. An examination of the Deglijareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 37: 29-38.

Watanabe, A. and Y. Yamamoto, 1971. Algal nitrogen fixation in the tropics. Plant and Soil, special volume, 403-413.

Watanabe, I., K. K. Lee, B. V. Alimagno, D. C. Sato, D.C. Del Rosario and M. R. De GuzMan, 1977. Biological N_2 fixation in paddy field studies by *in situ* acetylene-reduction assays. IRRI Res. Pap. Ser., 3: 1-16.

Yoshida, T. and R.R. Ancajas, 1973. Nitrogen fixing activity in upland and flooded rice fields. Soil Sci. Soc. Amer. Proc., 37: 42-46.