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Effect of cyanobacteria on growth and yield of boro rice under different levels of urea

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Abstract

A pot culture and a field experiment were conducted with cyanobacteria in presence and absence of different levels of urea to evaluate their effects on growth and yield of rice cv. BRRI Dhan 28, 29 and 36 during Boro season of 2007. The treatments were T_1 (control), T_2 (only cyanobacteria), T_3 (recommended doses of urea - 60 kg N/ha), T_4 (45% recommended doses of urea + cyanobacteria), T_5 (65% recommended doses of urea + cyanobacteria) and T_6 (85% recommended doses of urea + cyanobacteria). The maximum values for different growth, yield and yield components (plant height, number of productive tillers/hill, panicle length, number of grains/panicle, 1000-grain weight, and grain, straw and biological yield) were observed in BRRI Dhan 29 under T_6 (85% recommended doses of urea + cyanobacteria) and lowest was observed in BRRI Dhan 28 under T_1 (neither urea nor cyanobacteria). Uses of cyanobacteria increased the yield of Boro rice varieties and decreased the use of urea by 15-20%.

***Keywords*:** Cyanobacteria and urea, growth and yield, boro rice.

Introduction

Rice is the staple food for more than 60% of the worlds' population and it is being grown in this sub-continent from time immemorial. Nitrogen (N) is an essential nutrient element for plants and is needed in large quantities for high yield of crops. Bangladesh soils are deficient in N and consequently the response of modern rice varieties to N application has always been observed remarkable (Chowdhury & Bhuiyan, 1999). The N deficiency is one of the most common yield limiting factors in rice soils of Bangladesh (Mian, 1994). Application of N through different sources influences the activity of the microbes involved in the N transformation, and in turn, the availability of inorganic N increases in soil and yield of rice improves. Unfortunately, the N reserve of Bangladesh soil is very low (Islam, 1984) and supplementary use of N is essential for better crop production. Moreover, urea depletes the organic matter status in soils (Sattar, 1972). The high price and scanty of nitrogen fertilizer is one of the problems for rice production in rice producing countries. Biofertilizer is the cheaper source of nutrients in soil and is friendly to environment.

Cyanobacteria are a diverse group of procaryotes. In view of the global energy crisis, bio-fertilizers such as cyanobacteria and A*zolla* are important supplementary nitrogen sources in rice cultivation (Chowdhury & Bhuiyan, 1999). Additionally, cyanobacteria bring about changes in chemical and electro-chemical properties of the soil. This can modify the oxidation-reduction status of the rice growing soil and the chelating capacity of the soil organic matter, which in turn may bring about changes in the availability of different micronutrients like Fe, Cu, Zn in soil. The use of cyanobacterial bio-fertilizer for rice culture has been gaining importance due to increased crisis and production cost of nitrogen fertilizer especially in developing counties like Bangladesh. The farmers of Bangladesh grow rice during Boro season with irrigation water maintaining a 3-5 cm water level for at least 30-40 days and this time should be sufficient for growing large amounts of cyanobacteria (Sattar, 1972). Moreover, the production technology of cyanobacteria is easy and it does not require an extra land. Thus, there is an ample scope of growing cyanobacteria simultaneously with Boro rice. The present experiment was conducted to finding out the effects of cyanobacteria and urea on Boro rice in earthen pots and to determining the effect of cyanobacteria on Boro rice during their growing seasons in the experimentation fields.

Materials and methods

A pot culture experiment and a field experiment were conducted at Rajshahi University from Rajshahi during Boro season of 2007. The land was medium high having sandy loam in texture under the "High Ganges River Flood Plain" (AEZ-12) with pH 7.8, organic matter 1.18%, total N 0.09%, available P 15 µg/g soil, available K 0.165 meq/100g soil, available S 20 µg/g soil and available Zn 1.35 µg/g soil. The experiment was designed following a two factorial (variety and treatment combination) Randomized Complete Block Design (RCBD) where each treatments were replicated thries. The rice varieties were BRRI Dhan 28, 29 and 36. The treatments were T_1 = control (no urea or cyanobacteria), T_2 = only cyanobacteria, T_3 = recommended doses of urea (60 kgN/ha), T_4 = 45% recommended doses of urea + cyanobacteria, T_5 = 65% recommended doses of urea + cyanobacteria and T_6 = 85% recommended doses of urea + cyanobacteria. In case of pot culture experiment, bottom sealed earthen pots having 30 cm height and 40 cm diameter were used. The pots were filled with 15 kg soil leaving 10 cm height above for holding the water. The Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) at the rate of 180, 160 and 50 kg ha^{-1}, respectively were applied in all the pots before transplantation of the rice seedlings. Cyanobacteria were applied at the rate of 0.5 kg m^{-2} in pots and each lot was filled with water up to 4-5 cm. depths before inoculation (BARC, 1998). In field experiment, the unit plot size was 2.5 m X 2.0 m. Fertilizers were applied as the same rate used in pot. Total MP and TSP were applied during land preparation. Urea was applied with three equal splits at 20, 30 and 50 days after transplantation of seedlings.

The 30 days old seedlings of rice were transplanted having three seedlings per hill maintaining a spacing of 20 cm X 15 cm. Cyanobacterial inocula were applied @ 0.5 kg/m^2 (fresh weight) in the plots and each plot was filled with water up to 4-5 cm depths before inoculation. Irrigation water was applied when necessary to maintain about 5 cm of water height on the land surface. Intercultural operations were done when it was necessary. First weeding was done after 40 days and another after 50 days of transplanting. The excess seedlings were plucked out during first weeding. The field was irrigated twice. First irrigation was done at 40 days after transplanting second irrigation was done after 50 days of transplanting. Plants were harvested after attainment of their full maturity stage. Data on growth and yield contributing characters were taken. The values for grain and straw yield were calculated at 18±2% moisture content in pot and 22±2% moisture content in field trial. The findings from the experiments were analyzed statistically using

MSTAT – C package program. The mean values were compared by Duncun's Multiple Range Test (DMRT) along with the estimation of LSD value (Gomez & Gomez, 1984).

Results and discussion

Plant height

Plant height of three varieties of Boro rice were found to be vary among different treatments both in pot and field trails (Table 1). In pot trail, the highest plant height was found in BRRI Dhan 29 under T_1 and T_6 treatments and the lowest was observed in of BRRI Dhan 28 under T_1. In case of field trail, the highest plant height was also observed in treatment BRRI Dhan 29 under T_6 which was significantly different from that of all other treatments whereas the lowest was found in BRRI Dhan 28 or BRRI Dhan 36 under T_1 treatment. This finding agreed with the finding of Karim & Rahaman (1992). They obtained highest plant height and panicle length due to N_{60}+cyanobacteria treatment. The increased in plant height of rice as influenced by cyanobacteria were also reported Kannaiyan *et al*. (1989).

Table 1. Effect of cyanobacteria on the growth of boro rice with different levels of urea both in pot and field trails.

Varieties	Treat ments	Plant height (cm) at maturity stage		Number of productive tillers/hill		Panicle length (cm)		Number of grain/panicle	
		Pot trail	Field trail	Pot trail	Field trail	Pot trail	Field trail	Pot trail	Field trail
BRRI Dhan 28	T_1	67.5h	68.9i	8.3i	6.3i	16.5k	16.3j	83.9m	83.7k
	T_2	88.1d	81.3h	11.0h	11.0f	18.7hi	18.1hi	103.1k	97.3j
	T_3	93.2b	93.5c	20.7c	18.3bc	22.8d	22.8d	150.8ef	150.0e
	T_4	91.2c	79.4h	16.7f	16.7d	22.8d	18.4h	132.5hi	135.0g
	T_5	93.5b	91.5d	20.0cd	18.7bc	22.3e	22.2e	141.2g	140.0f
	T_6	93.5b	98.3b	22.3b	18.9bc	22.8d	23.0d	152.3e	156.3d
BRRI Dhan 29	T_1	83.5e	82.8g	9.7i	8.4h	17.8j	18.2hi	96.2l	95.0j
	T_2	89.5cd	87.5fg	12.3g	12.3e	21.6f	21.3f	118.0j	123.7i
	T_3	96.3a	98.7b	22.3b	21.0a	25.3a	25.3a	195.0b	228.1b
	T_4	91.4c	89.2ef	18.3e	18.3bc	22.8d	22.3e	169.0d	194.3c
	T_5	95.1b	97.7b	18.7e	20.7a	24.7b	24.3b	182.3c	227.7b
	T_6	98.0a	103.0a	23.7a	21.7a	25.3a	25.5a	202.0a	235.0a
BRRI Dhan 36	T_1	73.5g	70.0i	8.7j	6.7i	16.2l	16.1j	88.5 m	85.0k
	T_2	81.1f	80.6h	10.7hi	9.7g	18.5i	18.0i	99.0l	97.0j
	T_3	89.9cd	91.5d	19.0de	18.3bc	23.5c	23.5c	139.7g	135.0g
	T_4	93.5b	88.6f	15.7f	17.0d	19.6g	19.1g	130.0i	129.0h
	T_5	90.5c	90.8de	18.0e	18.6bc	23.4c	22.8d	134.3h	140.0f
	T_6	94.3b	94.0c	21.7a	18.7bc	23.8bc	23.9c	146.0f	147.7e
CV (%)		5.6	7.2	5.1	9.0	5.4	6.9	8.2	7.1

T_1 = control (no urea or cyanobacteria), T_2 = only cyanobacteria, T_3 = recommended doses of urea (60 kgN/ha), T_4 = 45% recommended doses of urea + cyanobacteria, T_5 = 65% recommended doses of urea + cyanobacteria and T_6 = 85% recommended doses of urea + cyanobacteria.

In a column and a variety, means followed by the same letter(s) are not differ significantly at 5% level of probability.

Number of productive tillers/hill

Table 1 shows that in pot experiment, BRRI Dhan 36 and BRRI Dhan 29 under T_6 produced maximum number of productive tillers/hill whereas the lowest number of productive tillers/hill was produced by of BRRI Dhan 28 and BRRI Dhan 36 under T_1. In field trial, maximum number of productive tillers/hill was found in BRRI Dhan 29 under T_3, T_5 and T_6 treatments and the lowest was observed in BRRI Dhan 28 and BRRI Dhan 36 under T_1. Such maximum number of tillers was obtained due to algal inoculation combined with nitrogen fertilizer (Sharma and Mishra, 1986). It was observed that cyanobacterial inoculation significantly increased the productive tillers up to about 30% per unit area (Aiyer *et al*., 1992) which strongly supports the present findings.

Panicle length

Panicle length in different varieties of Boro rice showed significant variation for the different treatments both in pots and field trials (Table 1). The BRRI Dhan 29 under T_3 and T_6 treatments produced the highest panicle length in pot trial whereas BRRI Dhan 36 under T_1 produced the shortest panicle. But in field, the BRRI Dhan 29 under T_6 treatment produced the tallest panicle whereas the BRRI Dhan 28 and BRRI Dhan 36 under T_1 produced the shortest panicle. It was observed that treatments with N fertilizer and cyanobacteria caused taller plant along with longest panicle and higher number of tiller/plant compared to that for urea alone (Kannaiyan *et al*., 1982).

Number of grain/panicle

Both in pot and field experiment, BRRI Dhan 29 under T_6 produced the highest number of grain/panicle while BRRI Dhan 28 and BRRI Dhan 36 under T_1 produced the lowest (Table 1). Highest number of filled grain/panicle was obtained due to split application of cyanobacteria with urea (Karim & Rahaman, 1992). Application of cyanobacteria with urea increased the number of grain/panicle both in pot and field trials (Rao *et al*., 1997). This finding agreed well with the present study.

1000-grain weight

In pot experiment, the 1000-grain weight was found maximum in BRRI Dhan 29 under T_6 and the lowest was observed in BRRI Dhan 28 and BRRI Dhan 36 under T_1 (Table 2). In field, the 1000-grain weight was observed maximum in BRRI Dhan 29 under T_3, T_5 and T_6 whereas the lowest was found in BRRI Dhan 28 under T_1. This finding almost agreed with the investigation of Suri & Puri (1994). They obtained highest 1000 grain weight by $BGA_{10}+N_{90}$ (cyanobacteria at 10 kg ha^{-1} and nitrogen at 90 kg/ha) in rice. On the other hand, it was also reported that 1000 grain weight was greater due to incorporation of cyanobacteria (Kannaiyan *et al*., 1982)**.**

Grain and straw yield

Grain and straw yield, varied significantly among the treatments both in pot and field experiments. The highest grain yield both in pot and field was observed in BRRI Dhan 29 under T_6 and the lowest was found in BRRI Dhan 28 under T_1 (Table 2). The highest straw yield was observed in BRRI Dhan 29 under T_6 and the lowest was found in BRRI Dhan 28 under T_1 both in pot and field experiment (Table 2). It was observed that the increase of grain yield over the control ranged between 3-14% with incorporation of cyanobacteria (Jagannathan *et al*., 1988). It was reported that direct application of cyanobacteria significantly increased the grain and straw yield of rice (Sharma, 1969). It was also observed that the effect of cyanobacteria alone or in combination with urea increased grain and straw yield (Venkataraman, 1979). It was stated that in areas where chemical N fertilizers were not used, only cyanobacterial inoculation gave the benefits of the farmers equivalent of applying 25-30 kg N ha^{-1}. Where N fertilizer was used, the dozes could be reduced by about one-third through cyanobacterial inoculation.

Table 2. Effect of cyanobacteria on the yield of boro rice with different levels of urea both in pot and field trails.

Varieties	Treat ments	Plant height (cm) at maturity stage		Number of productive tillers/hill		Panicle length (cm)		Number of grain/panicle	
		Pot trail	Field trail	Pot trail	Field trail	Pot trail	Field trail	Pot trail	Field trail
BRRI Dhan 28	T_1	19.3i	19.4i	154.4k	3.6i	4.6q	4.7m	8.2h	8.3g
	T_2	20.4h	20.5g	155.3h	4.2gh	5.3o	5.4k	9.5f	9.6f
	T_3	22.0d	21.9c	156.8c	5.5cd	7.3c	7.4cd	12.8c	12.9c
	T_4	21.0f	20.9f	155.5f	4.9ef	6.2l	7.3bc	10.9e	12.3cd
	T_5	21.9d	21.7d	156.1e	5.1de	6.6j	6.6gh	11.7d	11.7d
	T_6	22.0d	21.9c	156.6c	5.6d	6.9g	6.9e	12.4c	12.5c
BRRI Dhan 29	T_1	19.7i	21.f	154.7i	4.1gh	5.0p	5.l	8.9g	9.1f
	T_2	21.3e	22.2b	155.5f	5.3de	5.7n	5.7j	9.9f	11.0e
	T_3	22.6b	23.4a	157.6b	6.5b	7.6b	6.7f	14.4a	13.2b
	T_4	21.9d	22.3b	156.1d	5.9c	6.7i	7.2d	11.9d	13.2b
	T_5	22.2c	23.2a	157.7b	6.5b	7.1f	7.4b	13.8b	13.9b
	T_6	22.8a	23.4a	158.0a	7.1a	7.7a	7.8a	14.7a	14.9a
BRRI Dhan 36	T_1	19.8i	19.9h	154.9j	3.9hi	7.1e	5.2k	10.7e	9.1f
	T_2	20.8g	20.6g	155.6g	4.5fg	7.2d	7.0d	11.7d	11.5de
	T_3	22.0d	21.9c	156.0e	5.2de	6.1m	7.3cd	11.2cd	12.5c
	T_4	21.0f	21.0f	155.6f	4.9ef	6.5k	6.1i	11.3cd	10.9e
	T_5	22.0d	21.7d	156.1e	5.1de	6.8h	6.7h	11.8d	11.8d
	T_6	22.1c	21.5e	156.3e	5.8c	7.1ef	6.9ef	12.2c	12.7c
CV (%)		3.5	6.1	6.2	4.9	7.2	6.9	5.3	5.6

T_1 = control (no urea or cyanobacteria), T_2 = only cyanobacteria, T_3 = recommended doses of urea (60 kgN/ha), T_4 = 45% recommended doses of urea + cyanobacteria, T_5 = 65% recommended doses of urea + cyanobacteria and T_6 = 85% recommended doses of urea + cyanobacteria.

In a column and a variety, means followed by the same letter(s) are not differ significantly at 5% level of probability.

Biological yield

Data presented in Table 2 show that the BRRI Dhan 29 under T_3 and T_6 produced the highest biological yield in pot experiment. On the other hand, BRRI Dhan 28 under T_1 produced the lowest biological yield. In case of field experiment, BRRI Dhan 29 under T_6 was also produced the highest biological yield and BRRI Dhan 28 under T_1 produced the lowest (Table 2). Biological yield refers to the sum of grain and straw yields. Total yield (grain + straw) responded significantly to simultaneous growth of cyanobacteria with rice plants. The highest biological yield was found in BRRI Dhan 29 under T_6 and the lowest biological yield was found in BRRI Dhan 28 under T_1 both in pot and field experiments. It was reported that direct application of cyanobacteria significantly increased the grain and straw yield of rice (Sharma, 1969). Cyanobacteria reduced 15-20% use of nitrogenous fertilizers (urea) for optimum biological yield of Boro rice in the present study. The positive effects of cyanobacteria in increasing rice yields were also well reported Karim & Rahman (1992) and Antarikanonda & Amarit (1991).

Most of the farmers of the studied area were found unaware of the adverse effects of agro chemicals and beneficial effects of bio fertilizer. Their knowledge on unfavorable effect of chemical fertilizer on human health, soil and soil micro organisms, water and environment is very poor. Thus the farmers may be suggested for using cyanobacteria as well as other bio fertilizers reducing the amount of agro chemicals in the rice field.

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