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Effect of Organic and Inorganic Sources and Doses of Nitrogen Fertilizer on the Yield of Boro Rice

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Abstract

The experiment was conducted to study the effect of different sources and doses of nitrogen application on the yield formation of *boro* rice. Two *indica* modern *boro* rice varieties (BRRI dhan28 and BRRI dhan36) and 21 nitrogen fertilizer combinations were used in the experiment. The experiment was laid out in split- plot design with three replications by assigning varieties in the main plots and nitrogen fertilizers in the sub-plots. The unit plot size was 4m × 2m. Yield and yield contributing characters were measured. Among the two varieties BRRI dhan28 produced higher grain and straw yield. Grain and straw yields were increased with the increase of nitrogen rate up to 120 kg ha^{-1} at all the sources. In general, organic manures alone could not produce higher grain yield but the combination of organic and inorganic fertilizers produced higher yield. The application of 60 kg N ha^{-1} as urea with 60 kg N ha^{-1} as mustard oil cake (MOC) produced maximum grain and straw yield which was statistically similar to the yield of 50 kg N ha^{-1} as urea with 50 kg N ha^{-1} as MOC. The lowest values were found in control nitrogen application. The results suggest that replacement of 50% urea N by MOC was the best source of nitrogen considering higher yield of *boro* rice. Therefore, fertilization of BRRI dhan28 and BRRI dhan36 varieties of rice with 60 kg N ha^{-1} as urea and 60 kg N ha^{-1} as MOC or 50 kg N ha^{-1} as urea with 50 kg N ha^{-1} as MOC was found to be the best nitrogen rate among all the treatment combinations in respect of grain and straw yields.

Keywords: Cow dung, Mustard oil cake, Yield, Nitrogen, Urea, Boro rice

Introduction

Rice (*Oryza sativa*) is the staple food for nearly half of the world's population as well as for 148.10 million people (AIS, 2008) of Bangladesh. Rice plays absolutely dominant role in Bangladesh agriculture as it covers 77.96 percent of total cropped area (AIS, 2007). It contributes 14.6% to the national GDP (BBS, 2004). The yield level of rice is very low (2.43 t ha^{-1}, BBS, 2004) compared to other rice growing countries like South Korea and Japan where the average yield is 7.00 and 6.22 t ha^{-1}, respectively (FAO, 1999). It has already been reported that decreasing organic matter in farm soils has caused significant yield reductions (Islam, 1989). The low yield of boro rice is due to several factors. Sources of N fertilizer are an important factor for obtaining higher yields.

It is well known that inorganic fertilizers supply only nutrients in soil but organic manure supplies nutrients and at the same time improves soil quality. The long-term impact of chemical fertilizers on soils and environment is harmful. Use of unbalanced nutrients in the soils may be harmful in the long run causing soils an unproductive one. It is true that sustainable production of crops cannot be maintained by using only chemical fertilizers and similarly it is not possible to obtain higher crop yield by using organic manure alone (Bair, 1990). Proper identification and management of soil fertility problems are prerequisite for boosting crop production and sustaining higher yields over a long period of time. So use of organic manure in integration with inorganic fertilizers is very important in improving soil fertility and crop productivity. But sufficient information is not available about appropriate sources of organic manure and proper combination of organic and inorganic fertilizers suitable for rice based cropping system in Bangladesh to increase yield and improve soil fertility. Among the available organic sources of N, cow dung and mustard oil cake are rich in N content. Cow dung is the commonly practiced organic manure for crop cultivation in Bangladesh. It is an important source for supplying nutrients for crop production and is recognized as a substitute for inorganic fertilizers (Sharma and Mitra, 1991). The long-term research of BRRI reveals that addition of cow dung at the rate of 5 t ha^{-1} improved the rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Moreover, use of cow dung not only acts as a source of N and other nutrients but also increase the efficiency of applied nitrogen (Sarvanan *et al.*, 1987).

Nitrogen is the key element for crop production and it is required in larger amount compared with other fertilizers but it is a costly item when it is derived from artificial sources. But adding organic material from easy and available sources can minimize the cost. De Datta et al. (1981) reported that the low fertility of rice soils and a limited supply of inorganic fertilizers are the major constraints to increase rice yield in South and Southeast Asia. Improper use of fertilizers may reduce the yield of rice in spite of increasing the nitrogen rates. Efficient fertilizer management gave higher yield of crops and reduced fertilizer cost. (Hossain and Islam,1986). But the amount of fertilizer is in appropriate in most cases due to lack of proper knowledge and over 97% of the farmers do not follow the recommended dose of fertilizer (Hossain *et al*. 1981). It is essential to find out the optimum rate of nitrogen application for efficient use of this element by the plants for better yield.

Effort is needed to formulate an input package with a combination of organic and inorganic fertilizers. So that it will be technically effective and feasible, economically viable, socially and environmentally acceptable. But the research work for the use of cow dung and mustard oil cake as a source of N is rare. Therefore, the present study was conducted to evaluate the effect of organic and synthetic nitrogen and their combination on productivity of *boro* rice and the replacement of chemical fertilizer by organic fertilizer.

Materials and Methods

The experiment was conducted at the Agronomy Field Laboratory, University of Rajshahi, Bangladesh during December 2004 to May 2005. The experimental soil contained 7.58 pH, 1.45 % organic carbon, 0.14 % total nitrogen, 7.25 ppm available P, 176 ppm available K and 21 ppm available S. The experiment consisted of two modern rice varieties (BRRI dhan28 and BRRI dhan36) and 21 fertilizer combinations viz., T_1 (control), T_2 (60 kg N ha^{-1} as urea), T_3 (60 kg N ha^{-1} as cow dung), T_4 {60 kg N ha^{-1} as mustard oil cake (MOC)}, T_5 (30 kg N ha^{-1} as urea + 30 kg N ha^{-1} as cow dung), T_6 (30 kg N ha^{-1} as urea + 30 kg N ha^{-1} as MOC), T_7 (80 kg N ha^{-1} as urea), T_8 (80 kg N ha^{-1} as cow dung), T_9 (80 kg N ha^{-1} as MOC), T_{10} (40 kg N ha^{-1} as urea + 40 kg N ha^{-1} as cow dung), T_{11} (40 kg N ha^{-1} as urea + 40 kg N ha^{-1} as MOC), T_{12} (100 kg N ha^{-1} as urea), T_{13} (100 kg N ha^{-1} as cow dung), T_{14} (100 kg N ha^{-1} as MOC), T_{15}(50 kg N ha^{-1} as urea +50 kg N ha^{-1} as cow dung), T_{16} (50 kg N ha^{-1} as urea + 50 kg N ha^{-1}as MOC), T_{17} (120 kg N ha^{-1} as urea), T_{18} (120 kg N ha^{-1} as cow dung), T_{19} (120 kg N ha^{-1} as MOC), T_{20} (60 kg N ha^{-1} as urea + 60 kg N ha^{-1} as cow dung), T_{21}(60 kg N ha^{-1} as urea + 60 kg N ha^{-1} as MOC). The experiment was laid out in split- plot design with three replications by assigning varieties in the main plots and nitrogen fertilizers in the sub-plots. The unit plot size was 4m × 2m. The land was fertilized with 60 kg P_2O_5, 50 Kg K_2O, 10 Kg S and 4 Kg Zn ha^{-1} as basal dose in the form of triple super phosphate, muriate of potash, gypsum and ZnO, respectively by subtracting the amount coming from cow dung or mustard oil cake. Treatment wise required amount of cow dung and mustard oil cake were incorporated thoroughly with soil before 7 days of transplanting. Treatment wise nitrogen as urea, cow dung and mustard oil cake was applied in three equal splits at 15, 30 and 50 days after transplanting (DAT). The control plots received no nitrogenous fertilizer. 35 days–old seedlings were transplanted by hand at 20 cm x 15 cm spacing on 17 January 2005. All intercultural operations were performed as and when necessary. The date of harvest was determined, when 90% of the grains became golden yellow color. The harvested crop of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The bundles were dried on open sunshine, threshed and then seeds were cleaned. The seed and straw weights for each plot were recorded after proper sun drying.

Five hills (Except the two border rows hill and central $1m^2$ area) were selected randomly from each plot prior to harvest for collecting data on crop characters. The grain, straw, biological yields and harvest index were recorded from one square meter area of each plot at harvest. The data were analyzed statistically and adjudged the mean differences by Duncan`s New Multiple Range Test (DMRT) (Gomez and Gomez, 1984) with the help of computer package MSTAT-C.

Results and Discussion

Results showed that most of the yield components i.e. bearing tillers $hill^{-1}$, panicle length, number of grains $panicle^{-1}$, 1000- grain weight, grain yield, straw yield and biological yield studied were significantly influenced due to varieties. All the yield components studied varied significantly due to the application of different sources and doses of nitrogen.

Table 1. Effect of variety on yield and yield contributing characters of *boro* rice

Treatment	Plant height (cm)	Bearing tillers (no.)	Non-bearing tillers (no.)	Length of panicle (cm)	Grains panicle $^{-1}$ (no.)	Sterile spikelets panicle $^{-1}$ (no.)	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
BRRI dhan28(V_1)	92.22	9.28a	3.51a	22.84a	115.00a	12.35b	22.99	4.62 a	5.25 a	12.21
BRRI dhan36(V_2)	88.88	8.36b	3.03b	22.03b	110.00b	14.48a	23.23	4.34 b	4.93 b	14.34
CV(%)	10.55	5.46	20.24	6.86	5.31	6.60	5.88	7.28	7.58	4.81
Level of Significance	NS	0.01	0.05	0.05	0.05	0.05	NS	0.01	0.05	NS

In a column the figures bearing same letter (s) or without letter are identical and those having dissimilar letters differed significantly as per DMRT. V_1= BRRIdhan 28, V_2= BRRIdhan 28

Table 2. Effect of nitrogen sources and doses on yield and yield contributing characters of *boro* rice

Treatment	Plant height (cm)	Bearing tillers (no)	Non-bearing tillers (no)	Length of panicle (cm)	Grains panicle $^{-1}$ (no)	Sterile spikelets panicle $^{-1}$ (no)	Weight of 1000 grains (g)	Grain yield (t ha $^{-1}$)	Straw yield (t ha $^{-1}$)	Harvest index(%)
T_1	81.04gh	5.45k	2.33g	20.47j	86.11ef	13.90bc	22.37ef	2.51i	3.48h	41.90d
T_2	83.22e-h	7.40h	2.94c-g	21.47fghij	100.78h-k	11.67de	22.08f	3.42h	4.18g	45.00cd
T_3	86.18d-h	6.56j	2.72d-g	20.58ij	100.71i-k	13.31c	22.56d-f	3.37h	4.02g	45.60cd
T_4	82.58f-h	8.41f	2.37fg	22.43c-h	109.86e-h	10.17fg	23.14a-f	3.63h	4.04g	47.33a-c
T_5	85.80d-h	7.00i	2.56e-g	20.90h-j	94.70j-l	11.39ef	22.44ef	3.45h	4.12g	45.57b-d
T_6	83.89ef-h	8.41f	2.48e-g	21.87e-j	102.20ef	10.29fg	22.65def	3.59h	4.08g	46.81bc
T_7	85.54d-h	7.13hi	3.02c-g	21.28g-j	101.11g-i	11.33ef	22.65d-f	4.13g	4.83f	46.09bc
T_8	88.25c-g	5.59k	3.29c-g	21.28gh-j	91.38l	12.92cd	22.83d-f	4.27fg	4.92ef	46.46bc
T_9	84.19b-f	9.51d	3.15c-g	22.62c-g	110.16e-g	9.10g	22.92cd-f	4.72b-e	5.13def	47.92a-c
T_{10}	87.65c-g	7.40h	2.74d-g	22.22d-i	106.11f-i	11.37ef	22.36-f	4.41efg	4.95ef	47.12a-c
T_{11}	86.91d-h	8.89e	3.11c-g	22.80b-g	103.50f-j	10.80ef	22.80d-f	4.86b-d	5.52cd	46.82bc
T_{12}	92.67a-d	9.51d	3.67b-e	22.22d-i	123.68cd	13.88bc	23.33a-f	4.60d-f	5.26d-f	46.65bc
T_{13}	79.58h	8.09g	**4.58ab**	22.25d-h	111.62ef	14.63ab	23.08b-f	4.60d-f	5.28de	46.56bc
T_{14}	90.49b-e	10.43c	3.35c-g	22.37d-h	**142.27a**	13.56c	**24.31ab**	**5.52a-c**	5.92a-c	**48.68a**
T_{15}	88.82c-f	9.78d	3.55b-f	23.42a-e	131.05bc	14.00bc	23.20a-f	5.04bc	5.89bc	46.11bc
T_{16}	95.02a-c	11.35b	3.32c-g	23.75a-d	125.47b-d	13.73bc	23.48a-e	**5.75a**	**6.14ab**	48.36ab
T_{17}	**98.75a**	10.43c	3.99a-c	23.17a-e	118.17de	14.09bc	23.85a-d	4.71c-e	5.24d-f	47.34b
T_{18}	89.15b-f	9.76d	**4.81a**	22.96b-f	93.72kl	**15.40a**	23.33a-f	4.69c-e	5.54cd	45.85b-d
T_{19}	96.56ab	**11.43b**	3.60b-e	**24.68a**	**134.05ab**	13.87bc	**24.50a**	**5.60ab**	**6.02ab**	48.19ab
T_{20}	94.91a-c	10.47c	3.82a-d	24.08a-c	118.78de	**14.76ab**	23.26a-f	5.08b	5.89bc	46.31bc
T_{21}	**98.44a**	**12.34a**	3.39c-g	**24.38ab**	126.66 b-d	14.14a-c	24.23a-c	**5.85a**	**6.34a**	47.99b
CV(%)	10.55	5.46	20.24	6.86	5.31	6.60	5.88	7.28	7.58	4.81
Level of Significance	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

In a column the figures bearing same letter (s) or without letter are identical and those having dissimilar letters differed significantly as per DMRT.

T_1 =Control,, T_2= 60 kg Urea N ha^{-1}, T_3 = 60 kg CD N ha^{-1}, T_4 =60 kg MOC N ha^{-1}, T_5 =30 kg Urea N ha^{-1} + 30 kg CD N ha^{-1}, T_6 =30 kg Urea N ha^{-1} +30 kg MOC N ha^{-1} ,T_7 =80 kg Urea N ha^{-1}, T_8 =80 kg CD N ha^{-1}, T_9 =80 kg MOC N ha^{-1}, T_{10} =40 kg Urea N ha^{-1} +40 kg CD N ha^{-1} ,T_{11} =40 kg Urea N ha^{-1} +40 kg MOC N ha^{-1} ,T_{12}=100 kg Urea N ha^{-1}, T_{13} =100 kg CD N ha^{-1} , T_{14}=100 kg MOC N ha^{-1}, T_{15}=50 kg Urea N ha^{-1} +50 kg CD N ha^{-1} , T_{16}=50 kg Urea N ha^{-1} +50 kg MOC N ha^{-1} , T_{17}=120 kg Urea N ha^{-1} ,T_{18} =120 kg CD N ha^{-1} ,T_{19}=120 kg MOC N ha^{-1} ,T_{20}=60 kg Urea N ha^{-1} +60 kg CD N ha^{-1}, T_{21} =60 kg Urea N ha^{-1} + 60 kg N ha^{-1}MOC.

Table 3. Interaction effect of variety and nitrogen sources and doses on yield and yield contributing characters of *boro* rice

Variety × Nitrogen sources and doses	Plant height (cm)	Bearing tillers hill^{-1} (no)	Non Bearing tillers hill^{-1} (no)	Length of panicle (cm)	Grains panicle $^{-1}$ (no)	Sterile spikelets panicle $^{-1}$ (no)	Weight of 1000 grains (g)	Grain yield (t ha $^{-1}$)	Straw yield (t ha $^{-1}$)	Harvest Index (%)
V_1T_1	82.58	5.89o	2.42	19.40p	91.07pq	14.73a-e	22.53	2.75	3.49op	44.05
V_1T_2	84.87	7.82jk	3.12	21.17k-p	107.30i-n	9.32k-m	21.73	3.53	4.11mn	46.18
V_1T_3	87.68	7.00mn	2.91	20.90l-p	108.31h-m	10.16j-m	22.38	3.44	3.90n-p	46.85
V_1T_4	87.17	8.92h	2.37	22.40d-n	120.43d-h	9.18k-m	22.46	3.63	3.99n-p	47.64
V_1T_5	81.86	7.35lm	2.64	21.60i-o	94.43n-q	9.24k-m	22.23	3.47	4.03n-p	46.29
V_1T_6	84.45	8.92h	2.48	22.90b-k	105.36i-p	8.97lm	22.27	3.68	4.09no	47.36
V_1T_7	78.82	7.46kl	2.89	21.40j-o	105.89i-p	10.33j-l	22.48	4.23	5.41e-i	43.88
V_1T_8	73.96	6.02o	3.01	23.17a-j	88.10q-s	14.60b-e	22.84	4.51	5.13f-j	46.80
V_1T_9	86.46	10.00f	3.37	23.47a-h	114.44e-j	8.34m	22.57	4.84	5.42f-i	47.19
V_1T_{10}	81.73	7.78jk	2.74	22.57c-m	106.63i-o	11.51g-j	22.21	4.56	5.15f-j	46.98
V_1T_{11}	84.52	9.34g	3.23	23.73a-f	116.64e-i	10.90i-k	22.61	4.97	5.53c-g	47.35
V_1T_{12}	94.44	9.95f	3.85	22.07f-n	120.71d-h	13.59c-f	23.27	4.90	5.51d-h	47.06
V_1T_{13}	74.51	8.49i	4.82	23.70a-f	102.33j-p	13.58c-f	23.33	4.87	5.65b-f	46.31
V_1T_{14}	90.18	10.74cd	3.42	22.50d-n	145.38a	13.14d-g	24.48	5.64	5.86a-e	49.06
V_1T_{15}	89.21	10.20ef	3.75	23.97a-e	121.77d-h	13.56c-f	23.00	5.15	6.17ab	45.49
V_1T_{16}	98.74	11.77b	3.52	23.19a-i	140.78ab	13.99b-f	23.42	5.80	6.14a-c	48.59
V_1T_{17}	104.19	10.96c	4.12	23.63a-g	112.65f-k	13.74c-f	23.93	5.00	5.62b-f	47.10
V_1T_{18}	86.06	10.31ef	5.08	23.32a-i	75.31s	15.60ab	23.22	5.07	6.03a-d	45.66
V_1T_{19}	101.63	12.68a	3.68	24.62ab	131.80b-d	12.92e-h	24.58	5.80	6.33a	47.82
V_1T_{20}	99.90	10.46de	4.00	24.55ab	120.61d-h	15.08a-c	23.03	5.24	6.31a	45.37
V_1T_{21}	99.76	12.81a	3.62	24.73a	122.05d-g	13.94b-f	24.25	5.94	6.47a	47.88
V_2T_1	85.79	5.01p	2.19	20.77n-p	81.14rs	13.07d-g	22.21	2.26	3.46p	39.53
V_2T_2	87.49	6.97mn	2.84	21.77h-o	94.26o-q	14.02b-f	22.43	3.31	4.24k-n	43.84
V_2T_3	83.92	6.11o	2.62	20.27op	93.11p-r	16.47a	22.74	3.29	4.13mn	44.34
V_2T_4	89.32	7.90j	2.15	22.47d-n	99.28l-q	11.17h-j	23.82	3.63	4.10no	46.98
V_2T_5	85.91	6.65n	2.38	20.20op	94.97n-q	13.54c-f	22.64	3.42	4.20ln	44.86
V_2T_6	86.62	7.90j	2.26	20.83l-p	99.03m-q	11.61g-j	23.03	3.50	4.08no	46.19
V_2T_7	87.61	6.79n	2.61	21.17k-p	95.58m-q	12.32f-i	22.82	4.02	4.74j-l	47.32
V_2T_8	88.12	5.15p	2.73	20.17po	94.66 n-q	11.24h-j	22.81	4.03	4.72j-m	46.06
V_2T_9	88.83	9.02gh	2.28	21.77h-o	105.88i-p	9.86j-n	23.26	4.60	4.83i-k	48.76
V_2T_{10}	83.43	7.01mn	2.48	21.87g-o	95.58m-q	11.22h-j	22.51	4.26	4.24lk-n	48.65
V_2T_{11}	89.29	8.43i	2.85	21.87g-o	101.11k-p	10.69i-l	22.99	4.76	5.50d-h	46.38
V_2T_{12}	90.90	9.06jh	3.53	22.37d-n	121.31d-g	14.16b-e	23.39	4.30	5.61b-f	46.77
V_2T_{13}	84.64	7.68j-l	4.36	20.80m-p	120.91d-h	15.69ab	22.83	4.32	4.90h-j	46.84
V_2T_{14}	90.79	10.12ef	3.10	22.23e-n	139.16ab	13.97b-f	24.14	5.66	5.98a-e	48.64
V_2T_{15}	88.43	9.35g	3.45	22.87b-k	125.59c-e	14.43b-e	23.39	4.93	5.00g-j	46.25
V_2T_{16}	91.29	10.92c	3.18	24.30a-c	130.23b-d	13.48c-f	23.54	5.70	6.15ab	48.10
V_2T_{17}	97.11	9.90f	3.72	22.70c-k	115.51e-i	14.44b-e	23.77	4.42	5.48d-h	47.32
V_2T_{18}	92.24	9.20gh	4.60	22.60c-l	112.13g-l	15.20a-c	23.43	4.31	5.05f-j	46.06
V_2T_{19}	95.87	10.19ef	3.36	24.73a	136.29a-c	14.83a-d	24.42	5.69	6.01a-e	48.65
V_2T_{20}	85.63	10.47de	3.62	23.60a-g	123.69c-g	14.43b-e	23.48	4.92	4.86ij	47.65
V_2T_{21}	93.21	11.86b	3.28	24.03a-d	132.71a-d	14.33b-e	24.20	5.75	6.21ab	48.06
CV(%)	10.55	5.46	20.24	6.86	5.31	6.60	5.88	7.28	7.58	4.81
level of significance	0.05	0.05	NS	0.05	0.05	0.05	NS	NS	0.05	NS

In a column the figures bearing same letter (s) or without letter are identical and those having dissimilar letters differed significantly as per DMRT.

V_1= BRRIdhan 28, V_2= BRRIdhan 28

T_1 =Control,, T_2= 60 kg Urea N ha^{-1} , T_3 = 60 kg CD N ha^{-1} , T_4 =60 kg MOC N ha^{-1} , T_5 =30 kg Urea N ha^{-1} + 30 kg CD N ha^{-1} , T_6 =30 kg Urea N ha^{-1} +30 kg MOC N ha^{-1} ,T_7 =80 kg Urea N ha^{-1} , T_8 =80 kg CD N ha^{-1} , T_9 =80 kg MOC N ha^{-1} , T_{10} =40 kg Urea N ha^{-1} +40 kg CD N ha^{-1} ,T_{11} =40 kg Urea N ha^{-1} +40 kg MOC N ha^{-1},T_{12}=100 kg Urea N ha^{-1} , T_{13} =100 kg CD N ha^{-1} , T_{14}=100 kg MOC N ha^{-1}, T_{15}=50 kg Urea N ha^{-1} +50 kg CD N ha^{-1}, T_{16}=50 kg Urea N ha^{-1} +50 kg MOC N ha^{-1}, T_{17}=120 kg Urea N ha^{-1},T_{18} =120 kg CD N ha^{-1} ,T_{19}=120 kg MOC N ha^{-1},T_{20}=60 kg Urea N ha^{-1} +60 kg CD N ha^{-1}, T_{21} =60 kg Urea N ha^{-1} + 60 kg N ha^{-1}MOC.

Plant height

Plant height did not vary significantly due to varieties (Table 1) but it was varied significantly due to different sources and doses of nitrogen (Table 2). The highest plant height (98.75 cm) was observed in 120 kg N as Urea (T_{17}) which was statistically identical to T $_{21}$ (60 kg N ha^{-1} as urea + 60 kg N ha^{-1} as MOC) and the lowest plant height (81.04 cm) was found in control treatment. Plant height is dependent on the number of internodes and their length. It represents the varietal characteristics of a variety. The differences in plant height of different varieties might have been resulted from genetic make up of the cultivars, but the environmental factors also influence a little. The results were in agreement with Shamsuddin *et al.* (1988) and BINA (1993). Increasing levels of nitrogen up to 120 kg N ha^{-1} increased the plant height (Table 2). The increase in plant height due to application of increased level of nitrogen might be associated with stimulating effect of nitrogen levels on various physiological processes including cell division and cell elongation of the plant. These results are agreed with that of Kumar *et al.* (1995). Plant height did not show significant variation by the interaction of variety and nitrogen sources and doses (Table 3).

Number of bearing tillers hill^{-1}

Number of bearing tillers $hill^{-1}$ differed significantly due to variety. BRRI dhan28 and BRRI dhan36 produced higher (9.28) and lower (8.36) number of bearing tillers $hill^{-1}$ respectively (Table 1). Number of bearing tillers $hill^{-1}$ was significantly influenced by different doses and sources of nitrogen application. The maximum number of bearing tillers $hill^{-1}$ (12.34) was found in the application of 60 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as MOC (T_{21}) followed by T_{19} (120 kg N ha^{-1} as MOC) and T_{16} (50 kg N ha^{-1} as Urea + 50 kg N ha^{-1} as MOC) and the lowest number of bearing tillers $hill^{-1}$ (5.45) was found in control (Table 2). The reasons for differences in producing bearing tillers $hill^{-1}$ might be due to the variation in genetic make-up of the variety that might be influenced by heredity. This was consistent with Chowdhury *et al*. (1993). The number of bearing tillers increased with the increase of nitrogen levels up to 120 kg N ha^{-1} from all the sources. Variations in the number of bearing tillers among the different N sources were mainly due to their variations in the availability of N and other nutrients. Adequacy of nitrogen probably favored the cellular activities during panicle formation and development that led to increased number of bearing tillers $hill^{-1}$. Gosh *et al*. (1991) also agreed to this view. The interaction effect of variety and nitrogen sources and doses were significant for number of bearing tillers $hill^{-1}$. The interaction effect of BRRI dhan28 with 60 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as MOC ($V_1 \times T_{21}$) produced the highest number of bearing tillers $hill^{-1}$ which was statistically identical to $V_1 \times T_{19}$ but the lowest number of bearing tillers $hill^{-1}$ was obtained from the interaction of $V_2 \times T_1$(Table 3).

Non-bearing tillers hill^{-1}

The results revealed that there was significant difference in number of non-bearing tillers hil^{-1} between two rice varieties of obtaining 3.51 at BRRI dhan28 and 3.03 at BRRI dhan36 (Table 1). The number of non-bearing tillers hil^{-1} varied significantly due to different sources and doses of nitrogen (Table 2). It was observed that the highest non-bearing tillers $hill^{-1}$ (4.81) was found in the application of 120kg N ha^{-1} as Cowdung followed by T_{18} (100 kg N ha^{-1} as Cowdung) and the lowest 2.33 at control. There was no significant difference in the interaction effect of variety and sources and doses of nitrogen on number of non-bearing tillers $hill^{-1}$(Table 3).

Panicle length

Result showed the significant difference of panicle length between two varieties. BRRI dhan28 produced higher panicle length of 22.84 cm and the lower panicle length (20.47cm) was found in BRRI dhan36 (Tables 1). Panicle length was also highly significant for different nitrogen sources and doses. The highest panicle length 24.68 cm was found in T_{19} (120 kg N ha^{-1} as MOC) and the lowest panicle length (20.47cm) was found in control treatment (Table 2). The variation as assessed might be due to genetic characters of the varieties primarily influenced by the heredity. Diaz *et al.* (2000) also reported that panicle length varied among varieties. Results showed that panicle length increased with the increase of nitrogen rate. Nitrogen nutrient took part in panicle formation as well as elongation and for this panicle length increased with increase of N-fertilization. Idris and Matin (1990) reported similar results. Panicle length was significantly influenced by the interaction between variety and sources and doses of nitrogen. The longest panicle was found in the combination of $V_1 \times T_{21}$ (BRRI dhan28 with 60 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as MOC) but the shortest panicle was produced in $V_1 \times T_1$ combination (BRRI dhan28 with control treatment) (Table 3).

Number of grains panicle^{-1}

Number of grains panicle^{-1} was significantly influenced by the variety. The highest number of grains panicle^{-1} (115.00) were observed in BRRI dhan28 and the lowest number of grains panicle^{-1} (111.00) was found in BRRI dhan36 (Tables 1). There was a marked influence on number of grains panicle^{-1} by different levels and sources of nitrogen. The highest number of grains panicle^{-1} (142.27) was observed in 100 kg N ha^{-1} as MOC (T_{14}) followed by T_{19} and the lowest (86.11) was in control (Table 2). Varietal variation regarding the number of filled grains panicle^{-1} might be due to their variation in genetic constitutions and also due to variation in photosynthetic assimilate accumulation especially after heading. Moula (2002) reported variable number filled grains panicle^{-1}. Adequate supply of nitrogen contributed to grain formation, which probably increased number of grains panicle^{-1} with increasing nitrogen level. The present results explicitly confirm the similar results obtained by Chander and Pandey (1996) who recorded the highest number of grains panicle^{-1} at 120 kg N ha^{-1}. Bhuiya *et al*. (1989) also recorded the positive influence of nitrogen level on the production of number of grains panicle^{-1}. Significant influence was found on the number of grains panicle^{-1}due to the interaction effects between variety and sources and doses of nitrogen. The highest number of grains panicle^{-1} was found in the interaction of $V_1 \times T_{14}$ (BRRI dhan28 with 100 kg N ha^{-1} as MOC) but the lowest number of grains panicle^{-1} was produced in $V_2 \times T_1$ combination (BRRI dhan36 with control treatment) (Table 3).

Sterile spiklets panicle^{-1}

The number of sterile spikelets panicle^{-1} varied significantly between two varieties. The highest sterile spikelets panicle^{-1} 13.48 was found in BRRI dhan36 and the lowest 12.35 was obtained from BRRI dhan28 (Table 1). This variation might be due to genetic characteristics of the varieties. Nitrogen sources and doses were highly significant for sterile spikelets panicle^{-1}. Among the nitrogen sources and doses, it was the highest (15.40) at 120 kg N ha^{-1} as cow dung (T_{18}) followed by T_{20} (60 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as cow dung) and the lowest (9.10) was found at T_9 (80 kg N ha^{-1} as MOC (Table 2). Among the nitrogen sources, the maximum number of sterile spikelets panicle^{-1} was found in 120kg N ha^{-1} as cow dung (T_{18}) and the lowest one was obtained from 80 kg N ha^{-1} from MOC (T_9). Similar result was found by BRRI (1985) who reported that the application of only cow dung as a nitrogen source increased the sterility percentage (22%) over control (13%). The number of sterile spikelets panicle^{-1} varied significantly between the interaction effect of variety and sources and doses of nitrogen. The highest number of sterile spikelets panicle^{-1} was found in the combination of $V_2 \times T_3$ ((BRRI dhan36 with 60 kg N ha^{-1} as MOC) (Table 3).

Thousand grain weight

There was no significant variation for weight of 1000- grain in two rice varieties (Table 1). Application of different sources and doses nitrogen showed significant effect on 1000-grain weight. The highest 1000-grain weight 24.50g was found in T_{19} (120 Kg N ha^{-1} as MOC) followed by T_{14} (100 Kg N ha^{-1} as MOC) and the lowest 1000 grain weight (22.08g) was observed in T_2 (60 Kg N ha^{-1}) (Table 2). The variation in 1000-grain weight might be due to differences of length and breath of the grains that were partly controlled by genetic makeup of the variety under study. Chowdhury and Ghosh (1978) stated that 1000-grain weight highly varied due to variety ranged from 9.00 g to 23.00 g fine and scented rice varieties. The interaction effect due to variety and sources and doses of nitrogen did not affect the 1000-grain weight significantly (Table 3).

Grain yield

Varieties under study showed significant variation in grain yield. BRRI dhan28 produced higher grain yield 4.62 t ha^{-1} and BRRI dhan36 produced lower 4.34 t ha^{-1}(Table 1). Not only the number of effective tillers hill^{-1}, length of panicle, number of filled grains panicle^{-1}, 1000 grain weight were maximum which probably caused the highest grain yield. The yield of rice mainly depends on the yield contributing characters like the number of effective tillers hill^{-1}, number of grains panicle$^{-1,}$ weight of individual grain or thousand grains weight and number of spikelet sterility. Physiological parameters also play an important role on rice yield, which was supported by Cui-Jing *et al.* (2000). They obtained that higher rice yield possible by increasing total dry matter and harvest index. Grain yield differences due to varieties were also reported by Biswas *et al.* (1998). Results showed that there was a marked influence on grain yield by the application of different sources and doses of nitrogen. The highest grain yield (5.85 t ha^{-1}) was observed in T_{21}(60 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as MOC) which was statistically similar to T_{16} (50 kg N ha^{-1} as Urea + 50 kg N ha^{-1} as MOC) and T_{19}(120 kg N ha^{-1} as MOC) but the lowest grain yield (2.51 t ha^{-1}) was obtained from no nitrogen (Control) application (Table 2). Results revealed that a combination of organic and inorganic N sources resulted in comparable better rice yields. The grain yield progressively increased with the increase of organic manure. It might be due to the presence of organic manure that enhanced the effectiveness of chemical fertilizer. Liu *et al*. (1990) stated that the use of organic fertilizers in addition to chemical fertilizer increased soil OM and total N, increased the effectiveness of soil P. The increase in yield might be due to the contribution of more number of effective tillers hill^{-1}, panicle length, number of grains panicle^{-1} and 1000 grain weight. Balasubramaniyan (1984) reported that number of tillers hill^{-1}, number of grains panicle^{-1} and 1000-grain weight and ultimately the grain yield per unit area increased with increasing nitrogen application up to a range of 80 kg to 120kg N ha^{-1}. Similar trend was also observed by Karmakar and Ali (2006) and Islam *et al.* (2007a and b). Grain yield was insignificant due to the interaction between variety and sources and doses of nitrogen (Table 3).

Straw yield

Straw yield varied significantly due to variety. BRRI dhan28 and BRRIdhan36 produced higher (5.25 t ha^{-1}) and lower (4.93 t ha^{-1}) straw yield respectively (Table 1). Straw yield varied significantly by the application of different sources and levels of nitrogen. The highest straw yield (6.34t ha^{-1}) was observed in T_{21}(60 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as MOC) followed by T_{19} (120 kg N ha^{-1} as MOC) and the lowest straw yield (3.48 t ha^{-1}) was obtained from control (Table 2). The reasons for higher straw yield in the variety of BRRI dhan28 was due to its higher plant height and total tillers hill^{-1} i.e. the combined effect of plant height and tiller number. This result was supported by Chandra *et al.* (1992) who reported difference straw yield among varieties. Straw yield increased with the increase of N levels. Similar results were found by Karmakar and Ali (2006) and Islam *et al.* (2007a and b). Straw yield varied significantly due to the interaction of variety and sources and doses of nitrogen. The interaction effect of BRRI dhan28 with 60 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as MOC ($V_1 \times T_{21}$) gave the highest straw yield which was statistically identical to $V_1 \times T_{20}$ but the lowest straw yield was obtained from the interaction of $V_2 \times T_1$(Table 3).

Harvest index

Harvest index did not vary due to varieties but varied significantly by the application of different sources and doses of nitrogen (Tables 1 and 2). The highest harvest index 48.68% was found in T_{14} (100 kg N ha^{-1} as MOC) followed by T_{16} (50 kg N ha^{-1} as urea + 50 kg N ha^{-1} as MOC) and T_{19} (120 kg N ha^{-1} as MOC). The lowest harvest index (41.90%) was found in control. Insignificant influence was observed on HI due to the interaction effect of variety and sources and doses of nitrogen (Table 3).

Conclusions

For improvement and sustenance of rice productivity, integrated use of synthetic N and organic N sources is needed to be practiced. Besides the conventional sources of organic N like FYM and green manure, non-conventional sources like mustard oil cake can be used in rice field as a good source of organic N. Based upon the findings of the study following conclusions can be drawn:

BRRI dhan28 produced higher yields than BRRI dhan36. In general, organic manures alone could not produce higher grain yield but the combination of organic and inorganic fertilizers produced higher yield. The application of 60 kg N ha^{-1} as urea with 60 kg N ha^{-1} as mustard oil cake produced the highest grain and straw yields which were statistically identical to the yield of 50 kg N ha^{-1} as urea with 50 kg N ha^{-1} as mustard oil cake. It was further observed that replacement of 50% urea N by MOC was the best source of nitrogen considering higher yield of *boro* rice.

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