Effect of seed rate and nitrogen level on the yield of direct seeded hybrid *boro* rice

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Abstract: A field experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from January to May 2009 to evaluate the effect of seed rates and nitrogen levels on the yield of direct seeded hybrid *boro* rice. The experiment consisted of five seed rates viz., 9 kg ha^{-1}, 12 kg ha^{-1}, 15 kg ha^{-1}, 18 kg ha^{-1}, and 21 kg ha^{-1} with three nitrogen levels viz., 100 kg ha^{-1}, 120 kg ha^{-1} and 140 kg ha^{-1}. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The total number of effective tillers hill^{-1}, number of grains panicle^{-1}, grain yield, biological yield and harvest index were observed highest with 15 kg seed ha^{-1}. Again plant height, number of effective tillers hill^{-1}, number of grains panicle^{-1}, grain yield, straw yield and biological yield were found highest with140 kg N ha^{-1}. The highest total number of effective tillers hill^{-1} and highest grain yield were observed in the treatment combination of 15 kg seed ha^{-1} and of 140 kg N ha^{-1}. It was revealed that 15 kg seeds ha^{-1} with 140 kg N ha^{-1} was found to be adequate to produce maximum yield of direct seeded hybrid *boro* rice.
Key words: Seed rate, nitrogen level, direct seeded rice, hybrid *boro* rice

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereals of the world. Bangladesh ranks fourth in the world both in respect of area and production of rice (FAO, 1994) and 39th in yield per unit area (IRRI, 1995). The area and production of our country are 11.25 million hectares and 29.75 million tons, respectively (AIS, 2008). The population of Bangladesh is increasing day by day and horizontal expansion of rice area is not possible due to high population pressure, especially in rice production. Five million acres of agricultural land decreased during last 20 years (Anon, 2007). Hence, special attention should be given for increasing yield by applying nutrient retention practice in the soil, use of optimum dose of nitrogen fertilizer, proper seed rate high yielding varieties and/or hybrid varieties are considered to be the major determinants of yield of *boro* rice.

There are three major methods of rice crop establishment namely, transplanting, wet-seeding and dry seeding (Pandey, 1994). About 80 percent of the global rice growing areas are under transplanting method. Wet seeding methods are becoming popular to the farmers because the transplanting method requires high inputs, specially water and labor. The fertilizers are applied before final puddling or leveling. This is believed mainly in response to decrease labor costs associated with direct wet-seeding, and the emergence of cheap and effective herbicides for weed control (Denning, 1995). It is also getting popularity in a number of countries including Japan, Korea, Malaysia and Myanmar (Biswas, 1997). Though direct seeded method of rice, is not yet been widely adopted in Bangladesh has an opportunity to switch over. The optimum plant population per unit area is a major yield determining factor in wet-seeded rice. In the context of Bangladesh, it is essential to find out the optimum seed rate for the better performance for wet-seeded rice. Nitrogen is the top most important nutrient and it is the key input for rice production in the rice growing countries including Bangladesh. An increase in the yield of rice by 70-80 percent may be obtained by proper application of nitrogen fertilizer (IFC, 1982). Both lower and higher nitrogen rates, no doubt are detrimental to the crop growth and development. Efficient fertilizer management gave higher yield of crop and reduced fertilizer cost (Hossain and Islam, 1986). But the dose of nitrogen fertilizer is inappropriate in most of the cases due

to lack of information and over 97 percent of farmers do not follow the recommended dose (Hossain *et al.*, 1981). Chen and Chen (1989) reported that 21.2 percent more N uptake by hybrid varieties over conventional ones. Although a large number of experiments have been carried out to find out the optimum doses of nitrogen in rice in many places of the world including Bangladesh but, sufficient number of experiments have not yet been done in this regard especially with direct seeded hybrid rice varieties. Therefore, the experiment was conducted with the objectives of (i) To identify the optimum level of nitrogen for obtaining higher yield from direct seeded hybrid *boro* rice (ii) To identify the optimum seed rate to get optimum plant density for higher yield (iii) To determine the most suitable combination of seed rate and nitrogen level for obtaining higher yield from direct seeded hybrid *boro* rice.

Materials and Methods

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from January to May 2009 to determine the appropriate seed rate and the optimum level of nitrogen for higher yield of hybrid *boro* rice cv. Raichar-101. The land was medium high and the soil was silty loam. The pH value of the soil was 6.5. The soil was low in organic matter content and in fertility level. Status of phosphorus and cation exchange capacity (CEC) were medium and that of potassium was low. The experiment consisted of five seed rates viz., 9 kg ha^{-1}, 12 kg ha^{-1}, 15 kg ha^{-1}, 18 kg ha^{-1}, and 21 kg ha^{-1} with three nitrogen levels viz., 100 kg ha^{-1}, 120 kg ha^{-1} and 140 kg ha^{-1}. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Plot to plot distance was 0.5 m and block to block distance was 0.75 m. There were 45 plots and unit plot size was 4.0 m x 2.5 m. The phosphatic, potassic, sulphur, zinc and bron fertilizers were applied in the forms of Triple super phosphate, Muriate of potash, Gypsum and Zinc Sulphate at the time of final land preparation. Urea as per experimental specifications was top dressed in three equal splits at 15, 35, 55 days after sowing. The sprouted seeds were sown by broadcasting on as per experimental specifications. Intercultural operations like irrigation and drainage, weed management and pest control were done whenever necessary. Maturity of the crop was determined when

about 90 percent of the seeds were turned into golden color. Plants of 1 m^2 were selected randomly from each unit plot excluding border rows for collecting data on plant characters of rice. The harvested crop of each plot was separately bundled, properly tagged and then brought to the threshing floor. The grains were then threshed, cleaned, sun dried and weighed to record the grain yield. The grain yield was adjusted to 14 percent moisture content. Straw were similarly sun dried and weighed to record the straw yield. Grain and straw yields were finally expressed as t ha^{-1}. The collected data were analysed statistically. The analysis of data was done following MSTAT programme by computer. The mean differences among the treatments were adjudged with Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Effect of Seed Rate: From the result it was observed that plant height was not significantly influenced by seed rate. From Table 1 it is observed that, the seed rate of 15 kg ha^{-1} produced the highest total number of tillers hill^{-1} (10.84) and the lowest (10.22) was in 21 kg ha^{-1}. It was statistically identical with the seed rate of 12 kg ha^{-1} and 18 kg ha^{-1} (Table 1). The maximum number of bearing tillers hill^{-1} (10.80) was counted from the seed rate of 15 kg ha^{-1} and the minimum number of bearing tillers hill^{-1} (8.02) was found by the application of higher seed rate 21 kg ha^{-1} which was statistically similar with the other three seed rates (Table 1).

Table 1. Effect of seed rate on the yield of direct-seeded hybrid *boro* rice

Treatments (kg seeds ha^{-1})	Plant height (cm)	Total tillers hill^{-1}	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Grains panicle^{-1}	Unfilled grains panicle^{-1}	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
9	90.30	10.83c	8.35b	2.48b	124.40e	14.03c	24.78	3.49c	5.14bc	8.63b	40.72c
12	89.91	11.82b	8.50b	3.33a	139.40b	19.03a	24.78	3.67c	4.82c	8.48b	43.15b
15	87.94	13.24a	10.84a	2.41b	144.40a	11.92d	24.53	4.88a	5.14bc	10.02a	48.69a
18	87.08	10.92c	8.47b	2.45b	135.79c	15.76b	24.50	4.21b	5.58ab	9.79a	43.15b
21	87.11	10.22d	8.02b	2.20b	127.60d	18.32a	24.54	4.03b	5.71a	9.75a	41.61c
S($\bar{x}$)	1.16	0.20	0.18	0.16	0.75	0.55	0.08	0.08	0.16	0.20	0.70
Level of significance	NS	**	**	**	**	**	NS	**	**	**	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); * = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant.

This indicates that above and below 15 kg seeds ha^{-1} decreased the production of bearing tillers hill^{-1}. The highest number of non-effective tillers hill^{-1} (3.33) was found when used 12 kg seeds ha^{-1} and numerically the lowest number of non-effective tillers hill^{-1} (2.20) was found when used 21 kg seeds hill^{-1}, statistically similar results were found with the other three seed rates (Table 1). From Table 1 it is evident that the highest total number of grains panicle^{-1} (144.40) was found by the used of 15 kg seeds ha^{-1} and the lowest grains panicle^{-1} (124.40) obtained from 9 kg seeds ha^{-1}. It is therefore, concluded that less grains panicle^{-1} is obtained if the seed is increased or decreased from 15 kg ha^{-1}. The seed rate 21 kg ha^{-1} as well as 12 kg ha^{-1} produced the highest number of unfilled grains panicle^{-1} and the lowest number of unfilled grains panicle^{-1} produced by the treatment of 15 kg seeds ha^{-1} (Table 1). Statistically there was no significant effect of seed rate on 1000-grain weight. The result indicates that the highest grain yield (4.88 t ha^{-1}) was achieved from seed rate 15 kg ha^{-1}. The lowest grain yield (3.49 t ha^{-1}) was achieved from the seed rate 9 kg ha^{-1}, which was statistically identical to the seed rate 12 kg ha^{-1} (Table 1). The seed rate of 21 kg ha^{-1} produced the highest straw yield (5.71 t ha^{-1}), which was statistically identical with the seed rate of 18 kg ha^{-1}. The lowest straw yield (4.82 t ha^{-1}) was produced by the seed rate of 12 kg ha^{-1} which was statistically similar with the seed rate of 9 kg ha^{-1}, 12 kg ha^{-1}, 15 kg ha^{-1} (Table 1). The difference in the production of straw yield between low seed rate and high seed rate was possibly attributed to low plant density. Similar results were also obtained by Islam *et al.* (1994). The highest biological

yield (10.02 t ha^{-1}) was obtained when seed rate was 15 kg ha^{-1}, which was statistically similar with 18 kg seed ha^{-1} and 21 kg seed ha^{-1}. The lowest biological yield (8.48 t ha^{-1}) was obtained with the seed rate of 12 kg ha^{-1} which was statistically similar with 9 kg seeds ha^{-1} (Table 1). Seed rate significantly affected the harvest index at 5% level of probability. The highest harvest index (48.69%) was obtained when seeds were used at the rate of 15 kg ha^{-1}. The lowest harvest index (40.72%) was obtained when seeds were used at the rate of 9 kg ha^{-1} (Table 1).

Effect of N level: Effect of nitrogen level for plant height was significant. The tallest plant (91.15 cm) was found with 140 kg ha^{-1} of nitrogen while the shortest one (83.80 cm) was found when nitrogen dose was 100 kg ha^{-1}. Application of 120 kg N ha^{-1} produced statistical similar plant height with 140 kg N ha^{-1} (Table 2). Here it is obvious that the use of increasing N level was found to produce a positive effect on plant height of hybrid *boro* rice. The highest number of total tillers hill^{-1} (12.16) was found where nitrogen was applied at the rate of 140 kg ha^{-1} and the lowest number of total tillers (10.39) was found where N was applied at the rate of 100 kg ha^{-1} (Table 2). Nitrogen is an element which enhances vegetative growth of plants. Therefore, with the positive physiological effects the number of tillers hill^{-1} increased with the increase in nitrogen dose. The highest number (10.16) of effective tillers were found by the use of 140 kg N ha^{-1} and lowest number of effective tillers (7.41) were found when N was used at the rate of 100 kg ha^{-1} (Table 2). Adequacy of N probably favored the cellular activity during panicle

formation and development that led to increase the number tillers hill^{-1}. The results agreed with those of Balasubramaniyan (1984), Pandey *et al.* (1991) and Thakur (1993). The highest number of non-effective tillers hill^{-1}was found for 120 kg N ha^{-1}and 100 kg N ha^{-1} and these were statistically similar. The lowest number of non-effective tillers hill^{-1} (2.01) was found by the use of 140 kg N ha^{-1} (Table 2). It indicates that lower seed rate decreases the total number of non-effective tillers. The highest number of grains panicle^{-1} (143.30) was found with the treatment of 140 kg N ha^{-1} and the lowest number of grains panicle^{-1} (125.20) was found where N level was 100 kg ha^{-1} (Table 2) which is the indication of grains panicle^{-1} increased with the increased use of N level. It is obvious from the experiment that the highest number of unfilled grains panicle^{-1} (17.20) was produced with the treatment of 140 kg N ha^{-1} and statistically similar result was obtained from the treatment of 120 kg N ha^{-1}. The lowest number of unfilled grain panicle^{-1} was produced with the treatment 100 kg N ha^{-1} (Table 2). It was indicated that the number of unfilled grains increased with the increased of N level. The effect of seed rate on 1000-grain weight was not significant. The highest grain yield (4.31 t ha^{-1}) was obtained from 140 kg N ha^{-1}. But the lowest grain yield (3.74 t ha^{-1}) was obtained from 100 kg N ha^{-1}. Increase in grain yield due to application of nitrogen was mainly due to improvement of yield contributing characters like number of bearing tillers hill^{-1} and number of grains panicle^{-1} (Table 2). From the experiment it is obvious that the highest straw yield (5.62 t ha^{-1}) was obtained from 140 kg N ha^{-1} which was statistically similar with the treatment of 120 kg N ha^{-1}. The lowest yield (4.85 t ha^{-1}) obtained when nitrogen was used at the rate of 100 kg ha^{-1} (Table 2). From the experiment we found that the highest biological yield (9.93 t ha^{-1}) was obtained when nitrogen was used at the rate of 140 kg ha^{-1} which was statistically similar with the treatment of 120 kg N ha^{-1}. The lowest biological yield (8.59 tha^{-1}) was obtained with the treatment of 100 kg N ha^{-1} (Table 2). From the experiment it was numerically found that the highest harvest index (43.49%) was obtained from 140 kg N ha^{-1}. The lowest harvest index (43.42%) was obtained with the treatment of 100 kg N ha^{-1} (Table 2).

Table 2. Effect of nitrogen level on the yield of direct-seeded hybrid *boro* rice

Treatments (kg seeds ha^{-1})	Plant height (cm)	Total tillers hill^{-1}	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Grains panicle^{-1}	Unfilled grains panicle^{-1}	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
100	83.80b	10.39c	7.41c	2.98a	125.20c	13.38b	24.76	3.74c	4.85b	8.59b	43.42
120	90.45a	11.67b	8.94b	2.73a	134.45b	16.85a	24.58	4.12b	5.37a	9.49a	43.48
140	91.15a	12.16a	10.16a	2.01b	143.30a	17.20a	24.54	4.31a	5.62a	9.93a	43.49
S($\overline{X}$)	0.90	0.15	0.14	0.13	0.58	0.43	0.06	0.06	0.13	0.15	0.54
Level of significance	**	**	**	**	**	**	NS	**	**	**	NS

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT);
* = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant.

Interaction between Seed Rate and Nitrogen level:
Interaction of seed rate and nitrogen level did not produce any significant influence on plant height. The maximum tiller hill^{-1} (13.90) was found in 140 kg N ha^{-1} and 15 kg seeds ha^{-1} which was statistically similar with the use of 100 kg N ha^{-1} and 15 kg seed ha^{-1}. The lowest number of tiller (9.19) was found with the use of 100 kg N ha^{-1} and 21 kg seed ha^{-1}statistically similar with 100 kg N ha^{-1} and 9 kg seed ha^{-1}, 100 kg N ha^{-1} and 18 kg seed ha^{-1}, 120 kg N ha^{-1} and 21 kg seed ha^{-1} (Table 3). The highest number of effective tillers hill^{-1} (12.54) was with treatment combination of 15 kg seeds ha^{-1} and 140 kg N ha^{-1}and the lowest effective tillers hill^{-1} found when the combination was 9 kg seeds ha^{-1} with 100 kg N ha^{-1} which was statistically similar with the results obtain by the combinations of 12 kg seeds ha^{-1} and 100 kg ha^{-1}, 18 kg seeds ha^{-1} and 100 kg ha^{-1}, 21 kg seeds ha^{-1} and 100 kg ha^{-1}, 21 kg seeds ha^{-1} and 120 kg ha^{-1} (Table 3).
The maximum number of non-effective tiller hill^{-1} (4.20) was produced due to the combination of 100 kg N ha^{-1} and 12 kg seeds ha^{-1}, statistically similar result was found from the combination of 15 kg seeds ha^{-1}and 100 kg N ha^{-1}. The lowest number of non-effective tillers ha^{-1} was found by the combination of 15 kg seeds ha^{-1} and 140 kg N ha^{-1}.

Statistically similar result was found from the combinations of 100 kg N ha^{-1} and 18 kg seeds ha^{-1}, 100 kg N ha^{-1} and 21 kg seeds ha^{-1}, 140 kg N ha^{-1} and 9 kg seeds ha^{-1} and 140 kg N ha^{-1} and 21 kg seeds ha^{-1} (Table 3). The treatments combination of 15 kg seeds ha^{-1}and 140 kg N ha^{-1} produced highest grain panicle^{-1} (157.25). The lowest number of grain panicle^{-1} (121.51) was produced by the treatments combination of 21 kg seeds ha^{-1} and 120 kg N ha^{-1} (Table 3). The treatments 120 kg N ha^{-1} and 12 kg seed ha^{-1}, 140 kg N ha^{-1} and 12 kg seed ha^{-1} and 140 kg N ha^{-1} and 21 kg seed ha^{-1} produced statistically similar and highest number of unfilled grains panicle^{-1}. The lowest number of unfilled grains panicle^{-1} was produced with the combination of 120 kg N ha^{-1}and the seed rate 12 kg ha^{-1} (Table 3). Statistically there was no significant effect of seed rate and N level on 1000-grain weight. The highest grain yield (5.33 t ha^{-1}) was obtained with the combination of 140 kg N ha^{-1} and seed rate 15 kg ha^{-1}. The lowest grain yield (3.25 t ha^{-1}) was obtained with the combination of 100 kg N ha^{-1} and seed rate 12 kg ha^{-1} (Table 3) which is statistically identical with the treatments 100 kg N ha^{-1} and 9 kg seed ha^{-1}, 100 kg N ha^{-1} and 21 kg seed ha^{-1}, 120 kg N ha^{-1} and 9 kg seed ha^{-1}.The highest straw yield (6.50 t ha^{-1}) was produced with the combination of 140 kg N ha^{-1} and

seed rate 18 kg ha^{-1} which was statistically similar with the treatment combinations of 120 kg N ha^{-1} and 21 kg seed ha^{-1} and also 140 kg N ha^{-1} and 21 kg seed ha^{-1}. The lowest straw yield (4.62 t ha^{-1}) was obtained with the combination of 100 kg N ha^{-1} and seed rate 12 kg ha^{-1}; other treatment combinations were statistically identical with this (Table 3).

Table 3. Combine effect of seed rate and nitrogen level on the yield of direct-seeded hybrid *boro* rice

Treatments (kg seeds ha^{-1})	Plant height (cm)	Total tillers hill[-1]	Effective tillers hill[-1]	Non-effective tillers hill[-1]	Grains panicle[-1]	Unfilled grains panicle[-1]	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_1S_1	87.60	9.53h	6.67f	2.87bc	111.17i	12.93e	25.23	3.59ef	4.67d	8.26ef	43.41c-f
N_1S_2	85.37	11.20def	7.00f	4.20a	127.11g	14.17de	25.06	3.25f	4.62d	7.87f	41.29d-g
N_1S_3	84.00	12.80b	9.37cd	3.43ab	134.43f	9.28f	24.40	4.42c	5.25d	9.67bcd	45.74bc
N_1S_4	82.00	9.24h	7.03f	2.20c-f	126.83g	13.00e	24.64	3.92de	5.08d	9.00def	43.55c-f
N_1S_5	80.03	9.19h	7.00f	2.19c-f	126.47g	17.53bc	24.47	3.51ef	4.64d	8.15f	43.11c-f
N_2S_1	88.63	12.13bcd	9.47cd	2.67bcd	134.08f	14.73cde	24.48	3.50ef	5.17d	8.67def	40.53efg
N_2S_2	91.60	12.27bcd	9.13de	3.13bc	139.29de	21.03a	24.64	3.83de	4.83d	8.67def	44.23b-e
N_2S_3	91.63	13.03ab	10.60b	2.43cde	141.50cd	12.63e	24.81	4.90b	5.33cd	10.23abc	47.88b
N_2S_4	89.80	10.93efg	8.22e	2.72bcd	135.88ef	19.20ab	24.44	4.20cd	5.17d	9.37cde	44.93bcd
N_2S_5	90.60	9.97gh	7.28f	2.69bcd	121.51h	16.66bcd	24.53	4.17cd	6.33ab	10.50ab	39.83fg
N_3S_1	94.67	10.82fg	8.93de	1.89def	127.93g	14.43de	24.62	3.39f	5.58bcd	8.97def	38.22g
N_3S_2	92.77	12.00b-e	9.35cd	2.65bcd	151.81b	21.88a	24.63	3.92de	5.00d	8.92def	43.94cde
N_3S_3	88.20	13.90a	12.54a	1.36f	157.25a	13.87de	24.38	5.33a	4.83d	10.16abc	52.45a
N_3S_4	89.43	12.59bc	10.17bc	2.42cde	144.67c	15.07cde	24.42	4.50c	6.50a	11.00a	40.98d-g
N_3S_5	90.70	11.50c-f	9.79bcd	1.71ef	134.82f	20.77a	24.63	4.42c	6.17abc	10.59ab	41.89c-g
S($\bar{X}$)	2.00	0.34	0.30	0.28	1.30	0.95	0.14	0.14	0.28	0.34	1.21
Level of significance	NS	**	**	**	**	**	NS	*	**	*	**

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); N_1 = 100 kg ha^{-1}, N_2 = 120 kg ha^{-1}, N_3 = 140 kg ha^{-1}; S_1 = 9 kg ha^{-1}, S_2 = 12 kg ha^{-1}, S_3 = 15 kg ha^{-1}, S_4 = 18 kg ha^{-1}, S_5 = 21 kg ha^{-1}; * = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant.

Based on the result of the study, it may be concluded that the effects of seed rates and nitrogen levels treatments were highly significant. A seed rate of 15 kg ha^{-1} and nitrogen at the rate of 140 kg ha^{-1} should be used in case of direct seeded hybrid *boro* rice cv. Raichar-101.

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