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Effect of spacing on the growth and yield of boro rice (cv. BRRIdhan 36) under aerobic system

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Abstract: A field experiment was carried out at the Agronomy Field Laboratory, Department of Agronomy during February to June, 2008 to evaluate the effect of row to row and hill to hill spacing on the yield performance and yield of boro rice cv. BRRI dhan36 under aerobic system of cultivation. The experiment consists of three row to row spacing viz.; 20.0 cm, 25.0 cm and 30.0 cm and five hill to hill spacings viz. 2.5 cm, 5.0 cm, 10.0 cm, 15.0 cm and 30.0 cm. The trial was laid out in a randomiz complete block design with 3 replications. The crop sown at 20.0 cm row spacing gave the highest grain yield (3.99 t ha^{-1}). Similarly, the crop sown at 20.0 cm hill spacing produced the highest yield (4.44 t ha^{-1}). The results showed that the crop with 20.0 cm row to row spacing and 20.0 cm hill to hill spacing produced the highest grain yield (4.90 t ha^{-1}), whereas the lowest grain yield (2.55 t ha^{-1}) was found with 20.0 cm × 2.5 cm. The present study concludes that the highest grain yield of BRRI dhan36 during *Boro* season under aerobic system of rice cultivation could be possible on sowing at 20.0 cm × 20.0 cm spacing.
Key words: Spacing, growth, yield, boro rice, aerobic system

Introduction

Rice (*Oryza sativa* L.) is the most extensively cultivated crop in Bangladesh. It is the staple food crop for Bangladesh and more than half of the world's population. Rice demand would increase by 25% within 2025 to keep pace with population growth (Maclean *et al*., 2002). Bangladesh is an agro-based country. The country earns about 23.46% of her gross domestic production from agriculture (Kiron, 2003). Geographic and agronomic conditions of Bangladesh are favourable for rice cultivation. In the year 2006-2007, the total area and production of rice in Bangladesh is about 10.58 million hectares and 27.32 million tons, respectively (BBS, 2007). The area and the production of rice in the country are 11.26 million hectares and 29.75 million tons, respectively (AIS, 2008). In Bangladesh there are three distinct growing seasons of rice, namely *aus*, *aman* and *boro*. Among these three seasons, *boro* rice covers larger area of about 4.30 million hectares with a production of 14.95 million tons (BBS, 2007). Rice is an important target for water use reductions because of its relatively large water requirements compared with other crops (Li, 2001 and Wang *et al*., 2002). Aerobic rice is a new way of cultivating rice that requires less water than lowland rice. In "aerobic rice systems", rice is grown like an upland crop with adequate inputs and supplementary irrigation when rainfall is insufficient (Bouman, 2001). The water requirement of aerobic rice is potentially much less than that of flooded rice because of (1) the absence of water use for wet land preparation (puddling), (2) the absence of continuous seepage and percolation losses from the layers of ponded water and (3) the absence of evaporation losses from the ponded water layer (Bouman *et al*., 2005). Aerobic rice varieties also offer water savings for water-short lowland production systems. To fulfill the increased rice demand with shrinking resources, it will be necessary to increase yield in a unit area with less water (Zhao, 2006). The growth, yield and yield components of rice are greatly influenced by plant spacing. Optimum plant spacing ensures the plants to grow properly both in their aerial and under ground parts through efficient utilization of solar radiation and nutrients (Miah *et al.*, 1990). Proper spacing may help maximum light interceptions for better photosynthesis as well as yield of rice. Improper spacing may affect the physiological activities of rice plant and account for yield reduction to the extent of 26% to 30%. Various experiments and research works relating to the effect of spacing of transplanted wet land flood system of rice cultivation in *boro* season are available but under aerobic condition are scarce. The specific objectives of the study were: to find out the interaction effect of row to row spacing and hill to hill spacing on the yield and related characters of *boro* rice cv. BRRI dhan36 under aerobic condition.

Materials and Methods

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, during 18 February to 19 June 2008 to study the effect of spacing on yield and related characters of *boro* rice (cv. BRRI dhan36) under aerobic system of cultivation. The land was medium high with soil having sandy loam texture. The land was flat, well drained and above the flood level. The pH value of the soil was 6.45 (UNDP and FAO, 1988). Treatments included 3 row spacing is 20 cm (L_1), 25 cm (L_2), and 30 cm (L_3) and 5 hill spacings is 2.5 cm (P_1), 5 cm (P_2), 10 cm (P_3), 15 cm (P_4) and 20 cm (P_5). The experiment was laid out in randomized complete block design with three replications. Each treatment was randomly allocated in the respective plot. The unit plot size was 4.0 m × 2.5 m. The distances maintained between replications were 1.0 m and unit plots were 0.75 m and various intercultural operations were done for maintaining the normal growth and development of the crop. The crop was harvested when about 90% of the seeds became golden yellow in colour. Five hills (excluding border hills) were randomly selected in each plot and uprooted before harvesting for recording the necessary data on various plant characters. Data were analyzed using the analysis of variance (ANOVA) technique with the help of computer package programme MSTATC and mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Plant height: The results showed that the row to row, hill to hill and the interaction effect of row to row and hill to hill spacing did not show any significant effect on plant height (Table 1, 2 & 3). It was found that 5.0 cm hill to hill spacing produced the tallest plant (75.47 cm) whereas 15.0 cm hill to hill spacing produced the shortest

(72.85 cm). The tallest plant (77.29 cm) was obtained from 30 cm × 5 cm spacing and the shortest one (69.86 cm) was obtained from 20 cm × 15 cm spacing. It was observed that plant height decreased as spacing decreased.

Number of tillers hill^{-1}: It was observed (Table 1, 2 & 3) that the row to row, hill to hill and the interaction effect of row to row and hill to hill spacing had a highly significant effect on the number of tillers hill^{-1}. Effects on the number of total tillers hill^{-1} as influenced by 30.0 cm row to row spacing produced the highest (20.18) and the lowest one (15.40) was found in 20.0 cm row to row spacing. The highest number of tillers hill^{-1} (19.85) was produced from 20.0 cm hill to hill spacing whereas minimum number of tillers hill^{-1} (11.46) was found from 2.5 cm (Table 2). Wider spaced plants received more nutrient moisture and light which contributed to production of higher number tillers hill^{-1}. This confirms the findings of Haque and Nasiruddin (1988). It was also observed that BRRI dhan36 produced the maximum number of tillers hill^{-1} (22.81) at the row to row spacing of 20 cm × 15 cm and minimum number of tillers hill^{-1} (13.25) at the spacing of 25 cm × 2.5 cm (L_2P_1).

Number of effective tillers hill^{-1}: It was evident from Fig. 1 & 2 that row to row, hill to hill and the interaction of row to row spacing and hill to hill spacing had significant effect on the formation of number of effective tillers hill^{-1}. It was observed from the results that 20.0 cm hill to hill spacing produced the maximum number of effective tillers hill^{-1} (17.14). The number of tillers, specially the number of effective tillers hill^{-1} is one of the most important contributing characters forwards yield unit^{-1} area in rice. BRRI dhan36 produced the maximum number of productive tillers hill^{-1} (21.14) at spacing 20 cm × 20 cm and spacing 20 cm × 2.5 cm produced minimum number of effective tillers hill^{-1} (10.37).

Number of total spikelets panicle^{-1}: Number of total spikelets panicle^{-1} was significantly influenced by row to row, hill to hill and the interaction of row to row and hill to hill spacing. Table 1 show that the highest number of total spikelets (73.09) was obtained from 20.0 cm row to row spacing and the lowest number (65.90) was obtained from 30.0 cm row to row spacing. The highest number of total spikelets (76.24) was obtained from 20.0 cm hill to hill spacing (P_5) which was statistical identical to 15.0 cm hill to hill spacing (P_4) and the highest number of total spikelets (82.86) was obtained from the combination of L_1P_5 (20 cm × 20 cm spacing) which was statistically identical to 20 cm × 15 cm spacing (L_1P_5). On the other hand, the lowest number of total spikelets (53.75) was observed from the combination of L_3P_1 (30 cm × 2.5 cm spacing).

Number of grains panicle^{-1}: Number of grains panicle^{-1} was significantly influenced by row to row, hill to hill and influenced by row to row and hill to hill spacing. Fig. 3 shows that the highest number of grains (62.74) was obtained from 20.0 cm row to row spacing. The highest number of grains (61.98) was obtained from 20.0 cm hill to hill spacing (P_5) which was statistically identical to 15.0 cm hill to hill spacing (P_4). On the other hand, the highest number of grains (73.83) was obtained from the combination of L_1P_5 (20 cm × 20 cm spacing) and the lowest one (37.35) was observed from the combination of L_3P_1 (30 cm × 2.5 cm spacing).

Number of sterile spikelets panicle^{-1}: Number of sterile spikelets panicle^{-1} was significantly influenced by row to row, hill to hill spacing and interaction between row to row and hill to hill. The highest number of sterile spikelets (19.48) was obtained from 30.0 cm row to row spacing and the lowest one (10.35) was obtained from 20.0 cm row to row spacing (Table 1). Table 2 shows that the highest number of sterile spikelets (16.06) was obtained from P_2 (5.0 cm hill to hill spacing). The highest number of sterile spikelets (21.67) was obtained from the combination of 30 cm × 20 cm spacing (L_3P_5). On the other hand, the lowest number of sterile spikelets panicle^{-1} (8.58) was observed from the combination of 20 cm × 10 cm spacing (L_1P_3) which was statistically identical to L_1P_5 (20 cm × 20 cm spacing).

Weight of 1000 grains (g): Weight of 1000 grains shows that row to row, hill to hill and also the interaction between row to row and hill to hill spacing had no significant effect. It was found that the highest weight of 1000 grains (27.72 g) was obtained from 30.0 cm row to row spacing and the lowest one from 25.0 cm row to row spacing. On the other hand, Table 2 shows that the highest 1000 grains (27.86 g) was obtained from 2.5 cm hill to hill spacing and the lowest one (27.24 g) was obtained from 10.0 cm hill to hill spacing. The highest 1000 grains (28.63 g) was recorded from the combination of L_3P_3 (30 cm × 15 cm spacing) and the lowest one (26.55 g) was recorded from the combination of L_2P_4 (25 cm × 15 cm spacing).

Grain yield (t ha^{-1}): It was evident from analysis of variance that row to row, hill to hill and interaction between row to row and hill to hill spacing had significant effect on grain yield of BRRI dhan36. The result Fig. 5 showed that 20.0 cm row to row spacing produced the highest grain yield (3.99 t ha^{-1}) whereas 30.0 cm row to row spacing produced the lowest grain (3.44 t ha^{-1}) which was statistically identical to 25.0 cm (L_2) row to row spacing (3.48 t ha^{-1}) and 20.0 cm hill to hill spacing produced the highest grain yield (4.44 t ha^{-1}). On the other hand, the lowest grain yield (2.55 t ha^{-1}) was obtained from 25 cm × 2.5 cm spacing (L_2P_1) which was statistically identical to 30 cm × 2.5 cm spacing (L_3P_1) producing 2.63 t ha^{-1} grains.

Straw yield (t ha^{-1}): Straw yield was significantly influenced by the row to row, hill to hill and the interaction of row to row and hill to hill spacing. It was observed from Table 1 that 20.0 cm row to row spacing produced the highest straw yield (5.78 t ha^{-1}) and 20.0 cm row to row spacing produced the lowest straw yield (4.60 t ha^{-1}). It is also evident that 30.0 cm hill to hill spacing produced the highest straw yield (5.89 t ha^{-1}). The highest straw yield (6.83 t ha^{-1}) was recorded from the interaction of L_1P_5 (20 cm × 20 cm spacing) and lowest straw yield (3.38 t ha^{-1}) was recorded from the combination of L_2P_1 (25 cm × 2.5 cm) spacing.

Biological yield: Biological yield was significantly influenced by row to row, hill to hill and the interaction of row to row and hill to hill spacing. The highest biological yield (9.77 t ha^{-1}) was obtained from 20.0

cm row to row spacing (Table 1). Hossain (2002) reported that highest biological yield was obtained from wider spacing. The spacing 25 cm × 15 cm produced the highest grain and straw yields which resulted in the highest biological yield. Table 2 shows that the highest biological yield (10.33 t ha^{-1}) was obtained from P_5 (20.0 cm hill to hill spacing). The highest biological yield (12.73 t ha^{-1}) was recorded from the interaction of L_1P_5 (20 cm × 20 cm spacing) and the lowest one (6.72 t ha^{-1}) was recorded from the combination of L_3P_1 (30 cm × 2.5 spacing).

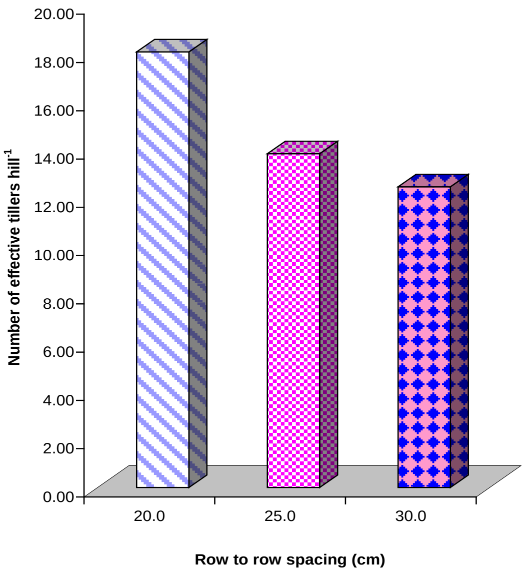

Fig. 1. Effect of row to row spacing on the number of effective tillers $hill^{-1}$ of *Boro* rice (cv. BRRI dhan36) under aerobic system of cultivation

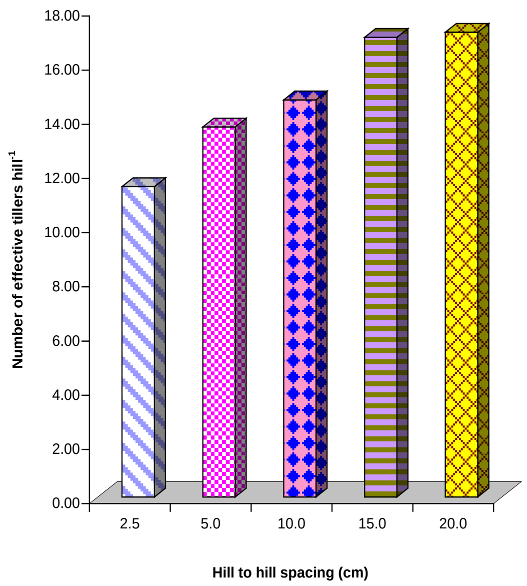

Fig. 2. Effect of hill to hill spacing on the number of effective tillers $hill^{-1}$ of *Boro* rice (cv. BRRI dhan36) under aerobic system of cultivation

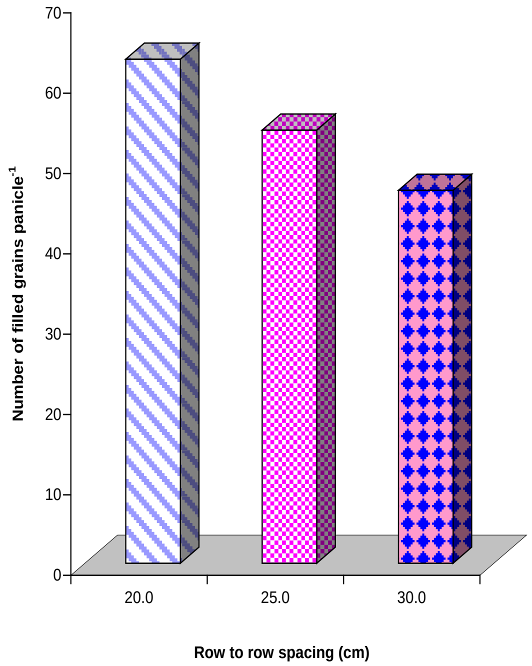

Fig. 3. Effect of row to row spacing on the number of filled grains $panicle^{-1}$ of *Boro* rice (cv. BRRI dhan36) under aerobic system of cultivation

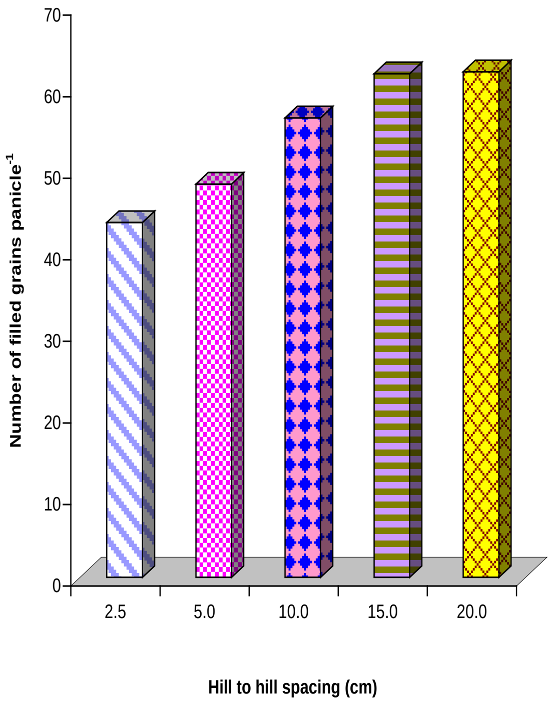

Fig. 4. Effect of hill to hill spacing on the number of filled grains $panicle^{-1}$ of *Boro* rice (cv. BRRI dhan36) under aerobic system of cultivation

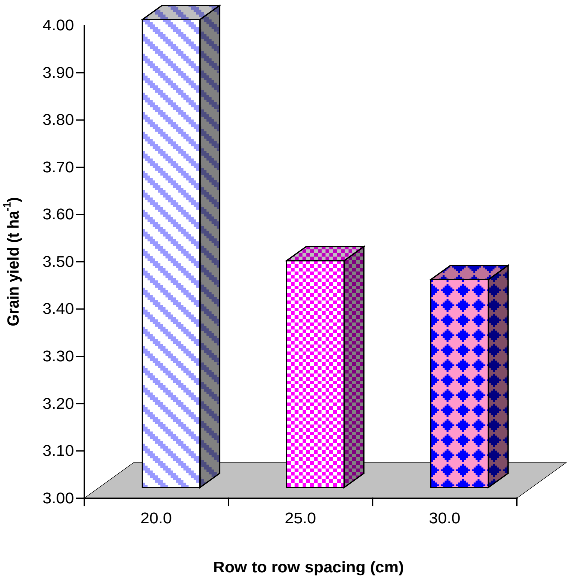

Fig. 5. Effect of row to row spacing on the grain yield of *Boro* rice (cv. BRRI dhan36) under aerobic system of cultivation

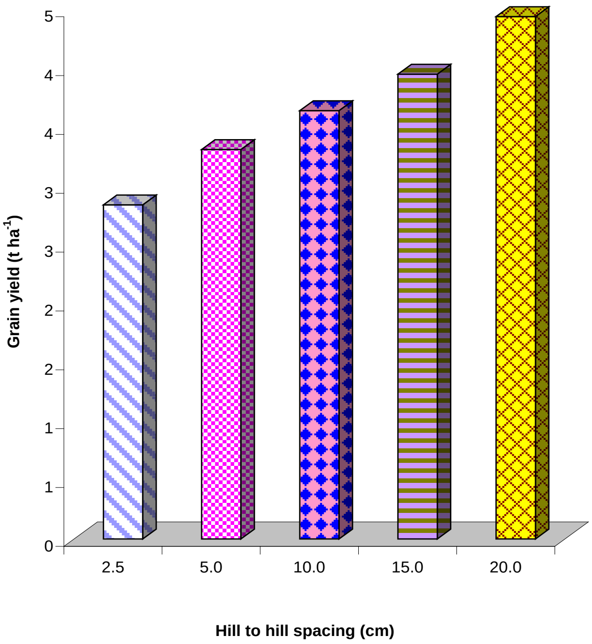

Fig. 6. Effect of hill to hill spacing on the grain yield of *Boro* rice (cv. BRRI dhan36) under aerobic system of cultivation

Table 1. Effect of row to row spacing on the growth and yield parameters of *Boro* rice cv. BRRIdhan 36 under aerobic system of cultivation

Row to row spacing	Plant height (cm)	No. of total tillers hill^{-1}	No. of total spikelet panicle^{-1}	No. of sterile spikelets panicle^{-1}	1000- grain weight (g)	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
20 cm	73.29	15.40c	73.09a	10.35c	27.61	5.78a	9.77a	40.79b
25 cm	74.31	16.93b	66.65b	12.73b	27.42	4.60b	8.08b	43.09a
30 cm	75.37	20.18a	65.90b	19.48a	27.72	4.74b	8.18b	41.81b
S$\bar{X}$	1.06	0.29	0.75	0.66	0.22	0.05	0.06	0.40
CV (%)	4.41	6.14	3.09	3.57	3.71	7.47	5.67	4.53
Level of Significance	NS	0.01	0.01	0.01	NS	0.01	0.01	0.01

In a column, figurers with letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT at 5% level.
NS = Not significant

Table 2. Effect of hill to hill spacing on the growth and yield parameters of *boro* rice cv. BRRIdhan 36 under aerobic system of cultivation

Hill to hill spacing	Plant height (cm)	No. of total tillers hill^{-1}	No. of total spikelet panicle^{-1}	No. of sterile spikelets panicle^{-1}	1000- grain weight (g)	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
2.5 cm	74.85	14.30c	57.89d	14.38	27.86	4.04d	6.87e	41.28b
5 cm	75.47	16.42b	64.28c	16.06	27.67	4.84c	8.15d	40.74b
10 cm	73.96	17.26b	69.50b	13.16	27.24	5.01c	8.66c	42.24ab
15 cm	72.85	19.69a	74.82a	13.06	27.55	5.43b	9.38b	42.19ab
20 cm	74.48	19.85a	76.24a	14.26	27.60	5.89a	10.33a	43.03a
S$\bar{X}$	1.37	0.37	0.97	0.85	0.29	0.07	0.08	0.52
CV (%)	4.41	6.14	4.09	3.57	3.71	7.47	5.67	4.53
Level of significance	NS	0.01	0.01	NS	NS	0.01	0.01	0.01

In a column, figurers with letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT at 5% level. NS = Not significant

Table 3. Interaction effect of row to row and hill to hill spacing on the growth and yield parameters of *boro* rice cv. BRRI dhan 36 under aerobic system of cultivation

Interaction (L × P)	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of total spikelet panicle^{-1}	No. of grains panicle^{-1}	No. of sterile spikelets panicle^{-1}	1000- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
L_1P_1	73.43	16.17e	13.53d	64.82de	52.03ef	12.78def	27.82	3.33fg	4.63f	7.96fg	41.81a-d
L_1P_2	74.89	18.28cd	15.27c	63.27e	53.88de	9.39ef	27.32	3.62de	5.49d	9.11de	39.71cd
L_1P_3	73.37	21.14ab	19.37b	72.69b	64.11c	8.58f	27.43	3.90c	5.85bc	9.75c	39.99bcd
L_1P_4	69.86	22.81a	20.93a	81.81a	69.86b	11.95def	27.47	4.20b	6.12b	10.32b	40.66bcd
L_1P_5	74.89	22.51a	21.14a	82.86a	73.83a	9.03f	28.00	4.90a	6.83a	11.73a	41.80a-d
L_2P_1	76.65	13.25h	10.37e	55.10f	41.14h	13.96cde	27.82	2.55h	3.38h	5.93i	42.94ab
L_2P_2	74.24	15.39ef	12.75d	65.85de	48.03g	17.82abc	28.34	3.19fg	4.37fg	7.56g	42.29abc
L_2P_3	74.50	16.64de	13.26d	66.73cd	56.35d	10.38ef	27.22	3.62de	4.55f	8.17f	44.31a
L_2P_4	72.93	19.48bc	16.13c	71.13bc	61.71c	9.42ef	26.55	3.85cd	5.11e	8.96e	42.93ab
L_2P_5	73.22	19.89bc	16.63c	74.42b	62.33c	12.09def	27.20	4.21b	5.58cd	9.79c	42.99ab
L_3P_1	74.45	13.47gh	10.47e	53.75f	37.35i	16.40bcd	27.95	2.63h	4.09g	6.72h	39.11d
L_3P_2	77.29	15.58ef	12.96d	63.72de	42.74h	20.98ab	27.34	3.13g	4.66f	7.79fg	40.22bcd
L_3P_3	74.00	14.00fg	11.33e	69.07bc	48.54g	20.53ab	27.07	3.41ef	4.63f	8.04f	42.42abc
L_3P_4	75.75	16.77de	13.83d	71.53bc	53.70de	17.83abc	28.63	3.81cd	5.05e	8.86e	42.98ab
L_3P_5	75.35	17.16de	13.72d	71.45bc	49.78fg	21.67a	27.61	4.20b	5.28de	9.48cd	44.31a
$S\bar{X}$	2.37	0.64	0.46	1.68	1.12	1.48	0.50	0.09	0.11	0.14	0.90
CV (%)	4.41	6.14	5.14	3.09	5.65	3.57	3.71	5.77	7.47	5.67	4.53
Level of sign.	NS	0.01	0.01	0.01	0.01	0.05	NS	0.01	0.01	0.01	0.01

In a column, figurers with letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT at 5% level; L_1 = 20 cm, L_2 = 25 cm, L_3 = 30 cm; P_1 = 2.5 cm, P_2 = 5 cm, P_3 = 10 cm, P_4 = 15 cm, P_5 = 20 cm; NS = Not significant

Harvest index: Harvest index was significantly influenced by row to row, hill to hill and also the effect of interaction between row to row and hill to hill spacing. The highest harvest index (43.09%) was obtained from 25.0 cm row to row spacing (Table 1). Similar results were observed by Kim *et al*. (1990). The highest harvest index (43.03%) was obtained from P_5 (20.0 cm hill to hill spacing, Table 2). The highest harvest index (44.31%) was recorded from the interaction of L_2P_3 (25 cm × 10 cm hill to hill spacing) which was statistically similar to L_3P_5 (30 cm × 20 cm hill to hill spacing) and the lowest harvest index (39.11%) was recorded from the combination of L_3P_1 (30 cm × 2.5 cm hill to hill spacing).

The experiment was consisted of three row to row spacing viz. 20.0 cm, 25.0 cm and 30.0 cm and five hill to hill spacing viz. 2.5 cm, 5.0 cm, 10.0 cm, 15.0 cm and 30.0 cm. The experiment was laid out in a randomized complete block design with 3 replications. The unit plot size was 4.0 m × 2.5 m (10 m^2) and the distance between blocks and plots were 1.0 and 0.75 m, respectively. In 2.5 cm spacing dry seed were sown in furrows maintaining seed to seed distance approximately 2.5 cm in the row where row to row distance was maintained as per treatments. From the results, the present study concludes that higher grain yield of *Boro* rice cv. BRRI dhan36 could be maximized by planting at 20 cm × 20 cm spacing under aerobic system of cultivation.

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