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Effect of row and hill spacing on the yield performance of boro rice (cv. BRRI dhan45) under aerobic system of cultivation

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Abstract

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2008 to April 2009 to evaluate the effect of row and hill spacings on the yield of rice (cv. BRRI dhan45) under aerobic system of cultivation in *boro* season. Aerobic system is a new water efficient rice production system where the crop is grown by direct seeding on well prepared dry beds and also by maintaining the soil moisture at field capacity during the growing period. The experiment consisted of two row to row spacings *viz.* 20 and 25 cm, and five hill to hill spacings viz., 2.5, 5, 10, 15 and 20 cm. The trial was laid out in a randomized complete block design with 3 replications. Results revealed that the crop sown at 25 cm ×15 cm produced the highest grain yield of 5.69 t ha^{-1} whereas the lowest grain yield of 2.11 t ha^{-1} was found with 20 cm × 2.5 cm spacing. The present study concludes that the highest grain yield of BRRI dhan45 during *boro* season under aerobic system of cultivation could be achieved by sowing at 25 cm ×15 cm spacing.

Keywords: Aerobic system**,** Boro rice, Hill spacing, Row spacing, Direct seeding

Introduction

Rice (*Oryza sativa* L.) is the most important food grain in Bangladesh. It is extensively cultivated throughout the year and it is also staple food crop in Bangladesh. Bangladesh is an agro based country; more than 80% population is directly dependent on agriculture. The soil and climate of Bangladesh are favorable for rice cultivation. In Bangladesh, about 77% of total cultivable land (14.42 million hectare) is used for rice cultivation. *Boro* rice is cultivated in about 4.7 million hectares of land and producing 18.6 million tons of rice (BBS, 2011). Rice is grown in three seasons namely *aus, aman* and *boro*. *Boro* rice occupies about 42% of total rice area contributing 55% of the total production. Therefore, *boro* rice is the main contributor to the food security in Bangladesh. *Boro* rice is mainly cultivated by puddled transplanting with flood irrigation. More than 80% of irrigation water comes from underground water source. The withdrawal of huge irrigation water causes lowering of ground water table and consequently causing serious environmental problems. The irrigation is done mainly by deep tubewell or shallow tubewells. Huge amount of electricity or diesel is required to operate these irrigation equipments. The scarcity of electricity or diesel in the country is increasing. The price of fuel is also increasing. Therefore, water saving boro rice production system is required under this water scarce to ensure food security. Currently, alternate wetting and drying (AWD) system of irrigation has been advocated towards saving irrigation water for boro rice but the water saving in this system is about 20-25% (Satter, 2009). On the other hand, 'aerobic system of rice cultivation' has been developed very recently where rice can be grown successfully with saving of 50-70% irrigation water (Bouman *et al.*, 2005, Peng *et al*., 2006). In aerobic rice system, rice is grown by direct seeding on well prepared unpuddled soil with supplemental irrigation. Unlike upland rice, the rice plant is highly responsive to inputs in aerobic system and the crop can produce similar yield to that of conventionally puddled transplanted system. Since, aerobic system offers water savings in rice cultivation, it could be adopted to sustain higher yield with less water in lowland boro rice production system towards attaining food security (Zhao *et al*., 1998).

Planting density is one of the most important factors determining the yield of rice. The growth, development and yield of rice are greatly influenced by plant spacing under field condition. Some farmers use close spacing while others use wide spacing. Closer spacing hampers intercultural operations, increases competition among the plants for nutrients, air, light, which results in weaker plants, mutual shading thus favours more straw yield than grain yield. On the other hand, wider plant spacing reduces grain yield $unit^{-1}$ area. Optimum plant spacing ensures the plant to grow properly with their aerial and underground parts by utilizing more solar radiation and nutrients (Miah *et al*., 1990). The maximum benefit in respect of rice yield can be obtained where planting is done with proper spacing. Many research

reports are available regarding the effect of spacing in conventionally transplanted rice cultivation in *boro* season (Miah *et al*., 1990, Verma *et al*., 2002; Rahman *et al*., 2004; Rahman and Taher, 2008; Rahman *et al.*, 2008) but research reports relating to the effect of plant density on boro rice production under aerobic system of cultivation is scarce. With view to the above discussion, an experiment was conducted aiming at evaluating the effect of row to row and hill to hill spacing on the yield performance of rice cv. BRRI dhan45 in *boro* season towards selecting the best spacing for rice under aerobic system of cultivation.

Materials and Methods

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2008 to April 2009. The area is located at 24°75' N latitude, 90°50' E longitude and at an altitude of 18 m. The land was medium high with moderate drainage facility and the soil was silt loam with pH value of 5.77. Soil contained 1.027% organic matter, 0.09% total N, 5.68 ppm available P, 49.12 meq 100 g^{-1} exchangeable K and 82.8 ppm available S. The boro season is colder with scanty rainfall. The study was conducted with a view to evaluate the effect of row and hill spacings on the yield of performance rice (cv. BRRI dhan45) under aerobic system of cultivation in *Boro* season. The experiment comprised (a) two row to row spacing *viz.*, 20 and 25 cm, and (b) five hill to hill spacings *viz.*, 2.5, 5, 10, 15 and 20 cm. The trial was laid out in a randomized complete block design with 3 replications. The unit plot size was 4.0 m × 3.0 m and the distances between blocks and unit plots were 1.0 m and 0.75 m, respectively. The land was prepared by country plough at field capacity and the sowing was done on 29 November 2008. The land was applied with 10 tons of cowdung at the time of land preparation. Fertilizers were applied @ 104, 15, 60, 15 and 1.5 kg N, P, K, S and Zn, respectively in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate. All the fertilizers except urea were applied during final land preparation. Urea was applied in four equal splits at 15, 30, 45 and 60 days after sowing. Seeds were primed by soaking in water for 24 h at room temperature followed by incubation at 35 ^{o}C for 30 h. After surface drying under shade, the primed seeds were dibbled directly in rows in the main field allocating four seeds $hill^{-1}$ as per experimental specification. Three hand weeding were done at 25, 50 and 60 days after sowing to control weeds. Experimental plots were irrigated 14 times to maintain normal growth and development of the crop. The soil was maintained at aerobic conditions during whole period of the season except for panicle initiation to flowering stage where wet condition was maintained. The crop was hand harvested at maturity. The harvesting was done on 29 April 2009 from the central 3 m x 2 m area. Five hills (excluding border hills) were randomly selected in each plot and uprooted before harvesting to record necessary data on various plant characters and yield attributes. The collected data on yield, plant characters and yield related attributes were analyzed statistically by using “Analysis of Variance Technique” and the means were compared following DMRT with the help of a statistical package programme MSTAT-C.

Results and Discussion

Effect of row to row spacing

The row to row spacing had significant effect on yield and yield contributing characters of rice (Table 1). Number of effective tillers $hill^{-1}$, non-effective tillers $hill^{-1}$ and sterile spikelet $hill^{-1}$ were affected significantly by row to row spacing while plant height, number of total tillers, panicle length, 1000-grain weight and harvest index remained unaffected. Higher grain yield (4.35 t ha^{-1}) was obtained from 25 cm apart row spacing due to the increased number of effective tillers $hill^{-1}$ (13.11). Higher straw yield (5.56 t ha^{-1}) and biological yield (9.89 t ha^{-1}) were obtained from 20 cm apart row spacing. The result is partially coincided with the result of Jalil (2008) who stated that the crop (cv.BRRI dhan29) with 25 cm row to row spacing produced the highest grain yield (5.87 t ha^{-1}) under aerobic system of cultivation. Lower grain yield (4.3t ha^{-1}) was obtained from 20 cm apart row spacing due to fewer effective tillers $hill^{-1}$ (12.8) and spikelets $panicle^{-1}$ (108.41). Lower straw yield (5.45 t ha^{-1}) and biological yield (9.82 t ha^{-1}) were obtained from 25 cm apart row spacing.

Table 1. Effect of row to row and hill to hill spacing on crop characters, yield and yield related parameters of BRRI dhan45 under aerobic system of cultivation in *boro* season

Spacing	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Row to row spacing												
20 cm	86.98	18.49	12.80 b	5.69b	21.88	108.41	15.74b	24.93	4.3b	5.56a	9.86a	42.73
25 cm	87.52	19.03	13.11a	5.92a	22.49	114.96	16.75a	24.78	4.35a	5.47b	9.82b	43.42
$S\overline{X}$	0.86	0.25	0.28	0.26	0.37	0.65	0.38	0.14	0.05	0.06	0.09	0.29
CV (%)	4.41	6.14	5.14	22.84	4.14	3.09	5.65	10.01	5.77	7.47	5.67	4.53
Level of Significance	NS	NS	**	**	NS	NS	**	NS	**	**	**	NS
Hill to hill spacing												
2.5 cm	87.35	17.16b	12.66	4.50b	22.05	82.50e	27.83a	24.49	2.11d	4.02c	6.13d	34.44c
5 cm	87.48	17.25b	13.10	4.14bc	22.14	109.90d	16.89b	25.08	4.47b	5.39b	9.86b	45.32a
10 cm	86.23	17.77b	15.01	2.76d	21.92	118.61c	9.11d	24.71	5.46a	6.45a	11.92a	45.99a
15 cm	87.55	17.87b	14.75	3.12cd	22.43	125.62a	12.24c	24.99	5.49a	6.49a	11.95a	45.68a
20 cm	87.63	23.75a	9.24	14.51a	22.39	121.80b	15.15b	25.01	4.10c	5.22b	9.32c	43.95b
$S\overline{X}$	1.35	0.40	0.44	0.40	0.58	1.03	0.60	0.23	0.08	0.09	0.15	0.46
CV (%)	4.41	6.14	5.14	22.84	4.14	3.09	5.65	10.01	5.77	7.47	5.67	4.53
Level of Significance	NS	**	NS	**	NS	**	**	NS	**	**	**	**

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

Effect of hill to hill spacing

Hill to hill spacing had significant effect on yield and yield contributing characters of rice (Table 1). Among the different yield attributes number of total tillers hill^{-1}, non-effective tillers hill^{-1}, grains panicle^{-1}, sterile spikelet panicle^{-1} were affected significantly. The highest grain yield (5.49 t ha^{-1}), straw yield (6.49 t ha^{-1}) and biological yield (11.95 t ha^{-1}) were obtained from 15 cm hill to hill spacing mainly due to the highest number of grains panicle^{-1} (125.62). The highest grain yield was possible due to combination of highest values for number of effective tillers hill^{-1}, number of grains panicle and 1000-grain weight. The lowest grain yield (2.11tha^{-1}), straw yield (4.02tha^{-1}), biological yield (6.13 tha^{-1}) and harvest index (34.44%) were obtained from 2.5 cm hill to hill spacing due to fewest grains panicle^{-1} (82.50) and the highest number of sterile spikelets panicle^{-1} (27.83). The result is in agreement with the report of Rashid (2009) who stated that the rice (cv. BRRI dhan36) with 2.5 cm hill to hill spacing produced the lowest grain yield (2.25 t ha^{-1}) under aerobic system of cultivation.

Effect of row to row and hill to hill spacing

The interaction effect of row to row and hill to hill spacing was significant for number of grains panicle^{-1}, number of sterile spikelets panicle^{-1} and grain yield but not for other yield contributing characters (Table 2). The highest number of grains panicle^{-1} was found with 25 cm × 5 cm spacing which was statistically similar to those with 20 cm × 15 cm, 25 cm × 15 cm and 25 cm × 20 cm spacings. The fewest grains panicle^{-1} was obtained with 20 cm × 2.5 cm spacing. The highest number of sterile spikelet panicle^{-1} was found with 25 cm × 2.5 cm spacing while the lowest was registered from 25 cm × 20 cm spacing. The highest grain yield (5.69 t ha^{-1}) was obtained from 25 cm × 15 cm. The result is at par with the result of Jalil (2008) who stated that the crop (cv.BRRI dhan29) with 25 cm × 15 cm spacing produced the highest grain yield (5.87 t ha^{-1}) under aerobic system of cultivation. These results might be due to availability of more nutrient, air and light in wider spacing which ultimately resulted in the production of more grain yield. The lowest grain yield (2.11 t ha^{-1}) was obtained from 20 cm × 2.5 cm which was identical to that from 25 cm × 2.5 cm (2.11 t ha^{-1}). This might be due to highest number of sterile spikelets panicle^{-1} (33.27). The highest sterility of spikelet at closest spacing reflects the high competition among the tillers for resources. The result is supported by the result of Rashid (2009) who stated that the crop (cv. BRRI dhan36) with 20 cm × 2.5 cm spacing produced the lowest grain yield (2.25t ha^{-1}) under aerobic system of cultivation. The present result, therefore, showed that 25 cm × 15 cm is the best for optimum growth and maximum yield for rice cv. BRRI dhan45. Mizan (2010) also found the highest yield at 25 cm × 15 cm spacing for transplanted boro rice cv. BRRI dhan45. In aman season, Rahman *et al.* (2004)

found the best performance of a transplant rice cv. BRRI dhan39 at 25 cm × 15 cm spacing. Hu *et al.* (1997) reported highest yield performance of rice at moderate spacing of 30 cm ×17 cm. The present study proves that rice could be cultivated at 25 cm x 15 cm spacing for highest production in unpuddle aerobic condition. The present study further revealed that planting at 25 cm × 15 cm spacing could be considered as the best practice for BRRI dhan45 both in aerobic direct seeded and puddle transplanted conditions.

Table 2. Interaction effect of row to row and hill to hill spacing on crop characters, yield and yield related parameters of BRRI dhan45 under aerobic system of cultivation in *Boro* season

Row to row × hill to hill pacing	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
20 cm × 2.5 cm	89.05	16.44	12.63	3.82	20.87	84.42d	22.39b	23.77	2.11f	4.17	6.28	33.60
20 cm × 5 cm	89.45	17.17	13.20	3.97	21.10	93.64c	14.82d	25.25	4.44d	5.31	9.76	45.45
20 cm × 10 cm	86.31	17.22	14.92	2.30	21.68	120.20b	9.82fg	24.83	5.67ab	6.60	12.26	46.24
20 cm × 15 cm	85.75	17.43	14.27	3.17	22.30	125.55a	11.19ef	25.44	5.23c	6.50	11.73	44.60
20 cm × 20 cm	84.33	24.19	8.99	15.20	23.44	118.25b	20.48bc	25.35	4.05e	5.20	9.25	43.77
25 cm × 2.5 cm	85.66	17.32	13.01	4.31	23.24	80.59d	33.27a	25.21	2.11f	3.87	5.97	35.29
25 cm × 5 cm	85.50	17.88	12.70	5.18	23.18	126.16a	18.96c	24.91	4.50d	5.46	9.96	45.18
25 cm × 10 cm	86.15	18.32	15.10	3.23	22.17	117.02b	8.40g	24.60	5.32bc	6.31	11.63	45.75
25 cm × 15 cm	89.35	18.30	15.24	3.07	22.55	125.68a	13.29de	24.54	5.69a	6.48	12.18	46.75
25 cm × 20 cm	90.92	23.31	9.48	13.83	21.33	125.35a	9.82fg	24.66	4.14de	5.24	9.38	44.14
$S\overline{X}$	1.91	0.56	0.62	0.57	0.82	1.46	0.85	0.32	0.12	0.13	0.21	0.65
CV (%)	4.41	6.14	5.14	22.84	4.14	3.09	5.65	10.01	5.77	7.47	5.67	4.53
Level of Significance	NS	NS	NS	NS	NS	**	**	NS	**	NS	NS	NS

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

Conclusion

Based on the result of the present study it could be concluded that the highest grain yield of rice cv. BRRI dhan45 could be obtained by planting at 25 cm × 15 cm spacing under aerobic system of cultivation in *boro* season.

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