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Short Communication

Optimizing Plant Spacing for Modern Rice Varieties

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Abstract

The experiment was performed under sub-tropical condition (24.75 N and 90.50 E) during the period of December 2011 to May 2012 to evaluate the effect of spacing on assimilate availability, yield attributes and yield of modern rice varieties. Four modern rice cultivars BINAdhan5, BINAdhan6, Iratom and BRRIdhan29 were sown with three spacing viz., 20 cm × 20 cm, 20 cm × 15 cm and 20 cm × 10 cm. The experiment was laid out in a split-plot design with four replicates. Wider spacing of 20 cm × 20 cm had shown superior performance in respect of all morpho-physiological and yield components, which resulted in the highest grain yield (8.53 t ha^{-1}). In contrast, closer spacing of 20 cm × 10 cm showed inferior performance in respect of above studied parameters and produced the lowest grain yield (6.47 t ha^{-1}). Among the cultivars, BRRdhan29 and BINAdhan6 performed the best regarding yield attributes and produced the highest grain yields (7.53 and 7.72 t ha^{-1}, respectively). The spacing of 20 cm × 20 cm may be recommended for cultivation of high yielding modern rice instead of recommended spacing of 20 cm × 15 cm after few more trials in farmers' field. © 2013 Friends Science Publishers

Keywords: Rice; Variety; Spacing; Growth; Yield

Introduction

The domestic production of rice can not entirely meet up the requirements of teeming hungry millions of Bangladesh. Due to the shortage of cultivable land, the scope of its extensive cultivation is very limited in this country. That is why special attention should be given for increasing the yield per unit area by applying improved technology and management practices. Among the cultural technologies, planting density is one of the important components, manipulation of which is an essence for optimizing yield (Faisul-ur-Rasool *et al.*, 2012). Various experiments on spacing of rice have been carried out in Bangladesh as well as in the other parts of the world to find out the suitable spacing for obtaining maximum yield (Mia, 1999; Thakur *et al*., 2009; Bozorgi *et al*., 2011).

Improper spacing reduced yield up to 20-30% (IRRI, 1997). The optimum spacing ensures the plant to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients (Khan *et al*., 2005; Mohaddesi *et al*., 2011). Plant spacing directly affects the normal physiological activities through intra-specific competition (Oad *et al.*, 2001). When the planting density exceed the optimum level, competition among plants for light above ground or for nutrients below the ground becomes severe and consequently the plant growth slows down and the grain yield decreases. On the other hand, wider space allows the individual plants to produce more tillers but it provides the smaller number of hills per unit area which results in low grain yield (Baloch *et al*., 2002; Vijayakumar *et al.*, 2004; Gozubenli, 2010; Kandil *et al*., 2010). Therefore, optimum plant spacing for a specific crop is needed to be explored. Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA) have developed some rice cultivars viz., BINAdhan5, BINAdhan6, Irratom24 and BRRIdhan29 which are producing more yield than the existing cultivars. But sufficient information regarding their optimum planting density under the agro-climatic condition of Bangladesh, have not been generated so far. Therefore, the present piece of research work was undertaken to find out the effective spacing for maximizing seed yield of some newly developed rice varieties in Bangladesh.

Materials and Methods

The experiment was conducted at the field laboratory of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh during December 2011 to May 2012. Four varieties viz., BINAdhan5, BINAdhan6, Iratom24 and BRRIdhan29 and three planting densities viz., 20 cm × 20 cm, 20 cm × 15 cm and 20 cm × 10 cm were included in the study. Mentionable that BRRI, the leading rice research organization in Bangladesh, has recommended the spacing of 20 cm × 15 cm for modern rice cultivars. Therefore, we included three planting densities of up and below of recommended spacing. The experiment was designed in two factors spit-plot with four replications, where spacings were placed in the main plot and varieties were placed in the sub-plot. The unit plot size was 4 m × 3 m. The land was fertilized with 220, 150, 130, 60 and 5 kg ha^{-1} of urea, triple superphosphate, muriate of potash, gypsum and zinc sulphate, respectively (BARC, 2005). One third urea and other fertilizers were incorporated with the soil at the final land preparation and rest of the urea was top dressed in two equal splits at 25 and 50 days after transplanting (DAT). Others standard cultural practices were followed to ensure the normal plant growth and development. Ten plants were randomly sampled for growth analysis from 50 DAT to 100 DAT at 25 days interval. The plants were separated into stem, leaves and roots and the corresponding dry weight were recorded after oven drying at 80 ± 2°C for 72 h. Leaf area was measured by LICOR leaf area meter (LI 3000A, USA) before drying. Absolute growth rate was measured following the formulae of Hunt (1978). The leaf chlorophyll was determined following the method of Yoshida *et al*. (1976). At maturity, all agronomic and yield contributing characters were recorded from 10 sample hills in each plot. The collected data were analysed statistically and mean separation was done by DMRT.

Results and Discussion

The effect of spacing on most of the studied morpho-physiological parameters like leaf area (LA) $hill^{-1}$, total dry mass (TDM) $hill^{-1}$, leaf area index (LAI) and absolute growth rate (AGR) was significant except chlorophyll content in leaves (Table 1). Results revealed that LA, TDM, AGR and chlorophyll content increased with increasing plant spacing, while LAI showed reverse trend. Varietal performance in case of above studied morpho-physiological characters showed that BRRIdhan29 performed the best in all the morpho-physiological parameters followed by BINAdhan6. In contrast, Iratom24 performed the lowest in most of the morpho-physiological characters. Considering the interaction of spacing and variety, the morpho-physiological characters was significant except chlorophyll content in leaf (Table 1). The TDM, LA and AGR increased with increasing hill spacing in all the varieties but the increment was not similar to all the varieties.

There was a remarkable difference in respect of yield and yield contributing characters due to spacing except panicle length, 1000-grain weight and harvest index (Table 2). Results revealed that number of total tillers, effective tillers, grain number and grain yield increased with increasing spacing with being the highest in the spacing of 20 cm × 20 cm. On the other hand, the lowest number of total tillers (50.5 m^{-2}), effective tillers (46.6 m^{-2}) and grain number (86.4 $panicle^{-1}$) was recorded in closer spacing of 20 cm × 10 cm, resulted in the lowest grain yield (31.6 g $hill^{-1}$ and 6.47 t ha^{-1}). Likely, the highest grain weight (39.1 g $hill^{-1}$ and 8.53 t ha^{-1}) was observed in wider spacing of 20 cm × 20 cm due to superiority in yield contributing characters (Table 2). However, panicle length, 1000-grain weight and harvest index were not significantly influenced by spacing indicating these three parameters were more or less stable under changing environment. Regarding varietal performance, results showed that BRIdhan29 produced the highest panicle length (22.8 cm) and number of filled grains (103 $panicle^{-1}$) with higher effective tillers (56.2 m^{-2}) resulting the higher grain yield (7.53 t ha^{-1}). Similarly, BINAdhan6 showed the highest grain yield (7.72 t ha^{-1}) due to production of higher number of effective tillers $hill^{-1}$ with second highest filled grains $panicle^{-1}$ (99.2). On the other hand, Iratom24 produced moderate yield (7.20 t ha^{-1}) although it produced the highest number of effective tillers (60.4 m^{-2}) and bolder grains (28.22 g per 1000-grain). This occurred might be due to the lowest number of grains $panicle^{-1}$ (82.4). The interaction effect of spacing and variety on yield attributes and yield was significant and any variety with 20 cm × 20 cm was the best regarding grain yield.

Population pressure had a major effect on morphological and physiological characters as well as yield. Leaf area $plant^{-1}$ was higher in wider spacing and lower in closer spacing. This might be due to limitation of light, nutrients and water in densely populated plants and vice-versa. As a result, more tillers as well as leaf area were produced in lower population levels (wider spacing), which have capacity to capture more sunlight because of less mutual shading effect among the leaves and less competition for nutrients in wider spacing plants producing greater TDM $hill^{-1}$ than closer spacing which resulted in higher AGR. Again, grain yield is strongly correlated with CGR as reported by Mohaddesi *et al.* (2011) in rice. This opinion is consistent with the results of the present experiment. In contrast, although in general LAI is positively correlated with yield but here result showed negatively associated with yield indicating maximum leaf was present in a specific area, which might have shading effect between them.

Although spacing had no significant effect on chlorophyll content and a/b ratio but there had a trend to increase with increase spacing. Chlorophyll a/b ratio increased in competition free plants in less-dense population because of better light penetration through the crop canopy. Chlorophyll a is responsible for the ultimate harvest of photons and chlorophyll b functions as an accessory pigment for shade adaptation (Dutta *et al.*, 1998). Thus, completion for light under high population pressure has been indicated.

In conclusion, the spacing of 20 cm × 20 cm produced better yield than the recommendated spacing of 20 cm × 15 cm due to superiority in morpho-physiological parameters. So, spacing of 20 cm × 20 cm should be followed for getting maximum grain yield of modern rice varieties in Bangladesh.

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Table 1: Effect of spacing, variety and their interaction on morpho-physiological characters in rice

Treatment		Leaf area hill^{-1} (cm^2)	Total dry mass hill^{-1} (g)	Leaf area index	Absolute growth rate (mg hill^{-1} day^{-1})		Total chlorophyll (mg g^{-1}fw)	Chlorophyll a/b Ratio
					50-75 DAT	75-100 DAT		
Spacing								
20 cm × 10 cm (S_1)		1155 c	106.8 c	6.56 a	9.26 b	4.18 b	3.05	1.30
20 cm × 15 cm (S_2)		1361 b	140.6 b	6.40 a	11.20 a	4.78 b	3.35	1.37
20 cm × 20 cm (S_3)		1548 a	167.1 a	5.90 b	11.42 a	6.49 a	3.25	1.45
F-test		**	**	*	**	**	NS	NS
Variety								
BINAdhan5 (V_1)		1217 c	138.3 b	6.36 a	11.13 a	4.60 b	2.95	1.33
BINAdhan6 (V_2)		1420 b	146.2 a	6.51 a	10.77 a	5.60 a	3.16	1.37
Iratom (V_3)		1244 c	118.4 c	5.19 b	9.85 b	4.83 b	3.17	1.39
BRRIdhan29 (V_4)		1538 a	149.7 a	6.36 a	10.75 a	5.55 a	3.26	1.41
F-test		**	**	**	**	*	NS	NS
Interaction of variety and spacing								
Variety	*Spacing*							
V_1	S_1	1031 g	108.5 d	6.80 a	9.90 b	3.90 e	2.79	1.28
	S_2	1231 f	143.6 b	6.89 a	11.70 a	4.70 bc	3.26	1.39
	S_3	1389 de	162.7 ab	5.79 b	11.80 a	5.20 b	3.31	1.40
V_2	S_1	1145 f	115.5 d	7.06 a	9.10 b	4.80 b	3.09	1.30
	S_2	1456 c	144.6 b	7.06 a	11.50 a	4.90 b	3.15	1.36
	S_3	1659 ab	178.6 a	6.42 b	11.70 a	7.10 a	3.21	1.47
V_3	S_1	1101 g	81.02 e	5.67 c	8.54 b	3.40 d	3.14	1.22
	S_2	1216 f	131.6 c	5.16 c	10.40 a	4.40 d	3.35	1.41
	S_3	1418 cd	142.5 b	5.13 c	10.60 a	6.70 a	3.30	1.55
V_4	S_1	1342 de	122.2 cd	6.72 ab	9.50 b	4.60 bc	3.18	1.42
	S_2	1544 b	142.6 b	6.49 ab	11.20 a	5.10 b	3.32	1.40
	S_3	1727 a	184.4 a	6.28 ab	11.56 a	6.95 a	3.28	1.41
F-test		*	**	*	**	**	NS	NS
CV (%)		8.05	8.23	7.11	6.06	8.10	5.01	4.98

Common letter (s) in a column within spacing, or variety or interaction of variety and spacing indicates do not differ significantly at $P \leq 0.05$ by DMRT; NS, not significant

DAT = Days after transplanting

Table 2: Effect of spacing, variety and their interaction on yield components and grain yield in rice

Treatment		Effective tillers m^{-2} (no)	Panicle length (cm)	Filled grains panicle^{-1} (no)	1000-grain weight (g)	Grain weight hill^{-1} (g)	Grain yield (t ha^{-1})	Harvest index (%)
Spacing								
20 cm × 10 cm (S_1)		46.6 c	22.0	86.4 b	26.54	31.6 c	6.47 c	54,24
20 cm × 15 cm (S_2)		58.2 ab	22.0	92.6 b	26.06	35.6 ab	7.25 b	54.00
20 cm × 20 cm (S_3)		65.8 a	22.1	101.0 a	25.99	39.1 a	8.53 a	54.85
F-test		**	NS	**	NS	**	**	NS
Variety								
BINAdhan5 (V_1)		53,6 b	22.7 a	89.4 c	25.96 b	34.9	6.80 b	52.21 b
BINAdhan6 (V_2)		57.3 a	22.2 a	99.2 b	25.93 b	36.9	7.72 a	52.90 b
Iratom (V_3)		60.4 a	20.5 b	82.4 d	28.11 a	35.2	7.20 b	59.70 a
BRRIdhan29 (V_4)		56.2 a	22.8 a	103.0 a	24.66 c	35.7	7.53 a	52.5 b
F-test		**	*	**	**	NS	*	**
Interaction of variety and spacing								
Variety	*Spacing*							
V_1	S_1	45.8 e	23.7	85.6 e	25.92	32.2 bc	6.36 e	52.53 b
	S_2	55.5 d	22.3	89.3 d	26.03	35.5 ab	6.93 d	51.20 b
	S_3	59.5 c	22.2	93.2 d	25.93	36.8 ab	8.01 b	52.89 b
V_2	S_1	46.8 e	21.4	86.2 e	26.30	33.1 bc	7.08 d	52.30 b
	S_2	58.0 d	22.4	98.0 b	25.77	37.6 ab	7.35 cd	52.20 b
	S_3	67.0 ab	22.8	113.0 a	25.71	40.0 a	8.73 a	54.30 b
V_3	S_1	46.5 e	20.2	78.7 f	28.09	31.1 c	6.15 e	60.00 a
	S_2	62.2 b	20.5	82.2 e	27.86	35.1 ab	7.49 c	60.40 a
	S_3	72.5 a	20.7	86.3 e	27.49	39.4 a	8.24 b	58.80 a
V_4	S_1	47.2 e	22.7	95.2 bc	24.94	31.8 c	6.30 e	52.15 b
	S_2	57.2 d	22.8	101.0 b	24.58	35.0 ab	7.42 c	52.00 b
	S_3	64.3 b	22.8	112.0 a	24.46	40.2 a	8.86 a	53.40 b
F-test		**	NS	**	NS	*	**	*
CV (%)		8.72	7.22	8.32	3.21	7.82	6.41	8.20

Common letter (s) in a column within spacing, or variety or interaction of variety and spacing indicates do not differ significantly at $P \leq 0.05$ by DMRT; NS, not significant

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References

Baloch, A.W., A.M. Soomro, M.A. Javed and M. Ahmed, 2002. Optimum plant density for high yield in rice. *Asian J. Plant Sci.,* 1: 25–27

BARC (Bangladesh Agricultural Research Council), 2005. Fertilizer Recommendation Guide, BARC, Farmgate, Dhaka-1215, Bangladesh

Bozorgi, H.R., A. Faraji and R.K. Danesh, 2011. Effect of plant density on yield and yield components of rice. *World Appl. Sci. J.,* 12: 2053–2057

Dutta, R.K., M.A.B. Mia, B.P. Lahiri, M.M. Uddin and M.M.A. Mondal, 1998. Growth and yield of lentil in relation to population pressure. *Lens Newslett.,* 25: 27–29

Faisul-ur-Rasool, R. Habib and M.I. Bhat, 2012. Evaluation of plant spacing and seedlings per hill on rice (*Oryza sativa* L.) productivity under temperate conditions . *Pak. J. Agric. Sci.,* 49: 169–172

Gozubenli, H., 2010. Influence of planting pattern and plant density on the performance of maize hybrids in the eastern Mediterranean condition. *Int. J. Agric. Biol.,* 12: 556–560

Hunt, R., 1978. *Plant Growth Analysis Studies in Biology*, pp: 67–71. Edward Arnold Ltd., London

Khan, M.B., T.A. Yasir and M. Aman, 2005. Growth and yield comparison of different linseed genotypes planted at different row spacing. *Int. J. Agric. Biol.,* 7: 515–517

IRRI (International Rice Research Institute), 1997. *Rice Production Manual,* p: 95. UPLB, Los Banos, The Philippines

Kandil, A.A., S.E. El-Kalla, A.T. Badawi and O.M. El-Shayb, 2010. Effect of hill spacing, nitrogen levels and harvest date on rice productivity and grain quality. *Crop Environ.,* 1: 22–26

Mia, M.H., M.S. Karim and M.S. Islam, 1999. Performance of Nigersail mutants under different row spacings. *Bangl. J. Train. Dev.,* 3: 31–34

Mohaddesi, A., A. Abbasian, S. Bakhshipour and H. Aminpanah, 2011. Effect of different levels of nitrogen and plant spacing on yield, yield components and physiological indices in high yield rice. *Amer-Eur. J. Agric Environ.,* 10: 893–900

Oad, F. C., B.K. Solangi, M.A. Samo, A.A. Lakho, Z.U. Hassan and N.L. Oad, 2001. Growth, yield and relationship of rapeseed under different row spacing. *Int. J. Agric. Biol.,* 3: 475–476

Thakur, A.K., S.K. Chaudhari, R. Singh and A. Kumar, 2009. Performance of rice varieties at different spacing grown by the system of rice intensification in eastern India. *Indian J. Agric. Sci.,* 79: 443–447

Vijayakumar, M., S.D.S. singh, N.K. Prabhakaran and T.M. Thiyagarajan, 2004. Effect of SRI practices on the yield attributes, yield and water productivity of rice. *Acta Agron.,* 52: 399–408

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