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PERFORMANCE OF DOUBLE GRAINED RICE CULTIVAR UNDER DIFFERENT PLANT SPACING

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A B S T R A C T

Plant spacing ensures uniform and optimum plant population and facilitates sufficient natural resources for crop growth which, in turns influences the crop yield positively. An investigation was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, during July to December 2017 to study the influence of plant spacing on the yield of double grained rice cultivar. The study comprised five spacing *viz*. 25 cm × 15 cm, 25 cm × 10 cm, 20 cm × 15 cm, 20 cm × 10 cm and 15 cm × 15 cm and two rice cultivars *viz*. a double grained rice cultivar and BRRI dhan49 and a double grained rice cultivar. It was laid out in a randomized complete block design with three replications. The double grained rice cultivar produced taller plant (155.65 cm), longer panicle (23.93 cm), higher 1000-grain weight (25.96) and higher straw yield (6.90 t ha^{-1}), though the higher grain yield (3.68 t ha^{-1}) was found in the test cultivar (BRRI dhan49). Planting at 20 cm × 15 cm produced the highest grain yield (3.70 t ha^{-1}) which was at par with 25 cm × 15 cm, 25 cm × 10 cm and 20 cm × 10 cm while planting at 15 cm × 15 cm produced the lowest grain yield (3.13 t ha^{-1}). The interaction of the double grained rice cultivar with all spacing combinations produced taller plants than the spacing combinations with BRRI dhan49. The higher grain yield (3.52 t ha^{-1}) was found in the double grained rice cultivar with 20 cm × 10 cm spacing which was at par with the spacing of 20 cm × 15 cm and 25 cm × 15 cm, respectively; although BRRI dhan49 always produced the higher yield. The lowest grain yield (3.08 t ha^{-1}) was recorded at the double grained rice cultivar with 25 cm × 10 cm spacing, however, the same treatment produced the highest biological yield (11.23 t ha^{-1}) due to the highest straw yield (8.15 t ha^{-1}). Hence, the spacing 20 cm × 15 cm might be recommended for the higher grain yield in the double grained rice cultivar.

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INTRODUCTION

Rice (*Oryza sativa* L.), the most consumed cereal worldwide, is also the staple food of Bangladesh. The tradition of rice farming in this land is being carried out across the generations and has become an integral part of Bengali culture. Irrespective of their social class, most of her people depend on rice as the primary source of their daily energy and nutritional requirement. Rice is grown round the year; however, have distinct three rice seasons prevailing in Bangladesh *viz*. *Aus*, *Aman* and *Boro*. As rice prefers moist soil conditions to grow, the farmers utilize rainwater for its cultivation when the country enjoys heavy monsoon rainfall during the *Aman* season. *Aman* rice accounts for 38.8% of total rice production and covers about 48.7% of land under rice cultivation in Bangladesh (BBS 2020). Due to the edaphic characteristics, favourable climatic conditions and recent agricultural innovations, Bangladesh has an abundance of local and modern (high yielding) rice cultivars. Different cultivars (and genotypes) have differences in their inherent characteristics, input requirements and environmental prerequisites.

Biram sundari, a double grained rice cultivar with a grain yield of 2.5 - 3.0 t ha^{-1} was reported from Birampur Upazila of Dinajpur district in Bangladesh, previously (Anon., 2012; Mitra et al., 2017). The multiple pistils are responsible for multiple grains within a single rice spikelet which is a very rare and unique feature in rice morphology (Sarwar and Chanda, 2018). Though a single grained spikelet is produced from a mono-pistillate ovary in the rice floret, around 254 genotypes with clustered spikelets were found in 26 countries of South and South-East Asia (Anon., 2012; Guarino, 2012). The double grained rice cultivar could be used to boost up the rice production in Bangladesh as it is well adapted to the local environment (Sarwar et al., 2020). A lot of research and extension activities are being carried out to acknowledge the increasing food pressure with decreasing cultivable lands. Still, the national average yield of *Aman* rice (3.2 t ha^{-1}) is much lower than the potential yield (BBS 2020). Though the reasons could be manifolds, the selection of cultivar and management practices should hold an important share. The inherent features of the yield contributing characters of a crop play an important role towards the yield accumulation. Genotypes are considered as an innate factor having a lot of contributions to the production of the yield components and yield of a crop as a result of the interactions with the growing environment (Tyeb et al., 2013; Shel et al., 2019). The right genotype can produce a good harvest when it is provided with proper agronomic management strategies. The genetic basis of the multiple grains in rice has already been described by many researchers (Mitra et al., 2017; Zhang et al., 2017; Ren et al., 2019; Zheng et al., 2019), however, the proper agronomic management practices i.e., population density, fertilizer and water management, pest control measures, etc., to improve or maximize grain yield are yet to be explored.

Plant spacing is an important crop management factor for transplanted rice. It acts as one of the key components of rice production technology (Dass et al., 2017) which has a role in governing all of the components of plants needed for growth and yield (Saha et al., 2020). The optimum plant spacing helps both the aerial and underground parts of a plant to utilize the solar radiation and nutrient elements for ensuring the proper growth and development (Rahman *et al*., 2007; Bhowmik et al., 2012; Paul et al., 2017). It has an influence on plant population, dry matter production, total tillers, effective tillers $hill^{-1}$, and number of grains $panicle^{-1}$ (Menete et al., 2008; Kuddus et al., 2020). Transplanting of rice maintaining optimum plant spacing could increase the grain yield by 4.7 to 12.2 % (Aggarwal and Singh, 2015). Thus, optimization of planting spacing may contribute to the yield gap reduction in different rice cultivars. Therefore, the present research was undertaken to study the performance of a double grained rice cultivar under different plant spacing (population density).

METHODOLOGY

Experimental Site and Design

The study was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU) during the *Aman* (July to December) season of the year 2017. The site belongs to 24°75' N latitude and 90°50' E longitude at an altitude of 18 m with non-calcareous dark grey floodplain soil under the Agro-ecological Zone (AEZ 9) of Old Brahmaputra Floodplain. It was a well-drained medium high land with a silty-loam texture having pH 6.5. Randomized complete block design (RCBD) with three replications was used. There were 30-plots and the area of each unit plot was 4.0 m × 2.5 m. The distance between blocks and plots were 1 m and 75 cm, respectively. The experiment consisted of two rice cultivars *viz*. BRRI dhan49 and a double grained rice cultivar, and five plant spacing *viz*. 25 cm × 15 cm, 25 cm × 10 cm, 20 cm × 15 cm, 20 cm × 10 cm and 15 cm × 15 cm. BRRI dhan49 was used as a test cultivar in the experiment.

Crop husbandry

The land was well prepared by ploughing and cross ploughing and fertilizers were applied as per recommendation. The whole amount of phosphorus, potassium, sulphur and zinc required for the unit plot was calculated and applied @105, 74, 65 and 12.5 kg ha^{-1} in the form of triple superphosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate, respectively. Urea @170 kg ha^{-1} was top-dressed in three equal splits at 15, 35 and 55 DAT (panicle initiation stage). Healthy seeds of a double grained rice cultivar were collected from the Laboratory of Plant Systematics, Department of Crop Botany, BAU and the seeds of BRRI dhan49 rice were collected from Agronomy Field Laboratory, BAU. Sprouted rice seeds were sown in a clean nursery bed to grow the healthy seedlings. Thirty day old seedlings were transplanted at the main field @ 3 seedlings hill^{-1} maintaining the spacing as per treatments. Weeding and other intercultural operations were done when required to ensure the normal growth of the crop. The crop was harvested when 90% of the grains became golden yellow in colour.

Data recording and Statistical analysis

Four hills (excluding border hills) were randomly selected from each unit plot prior to harvest for recording data on plant descriptors and yield components. The harvested crop was threshed, cleaned and dried to a moisture content of 14%. Grain and straw weight were recorded and converted into t ha^{-1}. Data were compiled and tabulated in the required format for statistical analysis. The collected data were statistically analyzed using the 'analysis of variance (ANOVA)' technique and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Performance of cultivars

Significant influence on yield and yield contributing descriptors of the rice cultivars were observed in case of genotypic difference except for biological yield (Table 1). The double grained rice cultivar gave the taller plant (155.65 cm), longer panicle (23.93 cm) and heaviest 1000-grain weight (25.96 g). In contrast, BRRI dhan49 gave the higher number of total tillers hill^{-1} (9.41), number of effective tillers hill^{-1} (8.53) and number of grains panicle^{-1} (138.85). Also, the higher grain yield (3.68 t ha^{-1}) and harvest index (36.14 %) were found in BRRI dhan49. The longer plant and panicle of the double grained rice cultivar could be due to its inherent characteristics as also observed by Sarwar and Chanda (2018). The double grained rice cultivar had a comparatively lower grain yield (3.33 t ha^{-1}) than BRRI dhan49. The lower grain yield might be due to higher number of sterile spikelets panicle^{-1} (24.48) in the double grained rice cultivar. But, it produced a higher straw yield (6.90 t ha^{-1}) possibly owing to the taller plant stature in the double grained rice cultivar. Yield is a cumulative performance of the vegetative and yield contributing descriptors of a plant which are often strongly controlled by the genetics and the environment of respective cultivar. Variable performance of the yield contributing descriptors and yield of rice exerted by the varieties was reported elsewhere (Tyeb et al., 2013; Islam et al., 2013; Sarkar et al., 2014; Verma et al., 2019).

Influence of plant spacing

Plant spacing exerted a significant impact on yield and yield contributing descriptors of the double grained rice cultivar and BRRI dhan49 except for panicle length and 1000-grain weight (Table 2). The tallest plant (137.5 cm) was found in 20 cm × 15 cm which was statistically similar to that of 25 cm × 15 cm and 25 cm × 10 cm. The highest number of total tillers hill^{-1} (9.46) and number of effective tillers hill^{-1} (8.42) were recorded in 15 cm × 15 cm. The highest grain yield (3.70 t ha^{-1}) was recorded in 20 cm × 15 cm which was statistically identical with that of 25 cm × 15 cm (3.58 t ha^{-1}), 25 cm × 10 cm (3.60 t ha^{-1}) and 20 cm × 10 cm (3.56 t ha^{-1}). The highest grain yield (3.70 t ha^{-1}) could be due to the statistically highest number of grains panicle^{-1} (137.5) in 20 cm × 15 cm (Figure 1 & 2). Optimum plant population could facilitate the highest sunlight penetration and maximize the utilization of the supplied and natural resources which enhanced the grain yield performance. Similar findings were revealed by Hossain *et al*. (2003), Bhowmik *et al*. (2012), Tyeb et al. (2013), Haque et al. (2015) and Shel et al. (2019). The lowest grain yield (3.125 t ha^{-1}) was found in 15 cm × 15 cm spacing. However, the highest straw yield (7.59 t ha^{-1}) and biological yield (11.18 t ha^{-1}) were found in 25 cm × 10 cm (Figure 3). Rahman et al. (2007) and Haque et al. (2015) also found similar findings in the case of spacing treatment.

Table 1. Effect of cultivar on yield contributing descriptors and yield of rice plant

Cultivar	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Length of panicle (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 (%)
BRRI dhan49	110.88 b	9.41 a	8.53 a	23.23 b	138.85 a	11.09 b	23.40 b	3.68 a	6.51 b	10.19	36.14 a
Double grained rice	155.65 a	7.48 b	6.85 b	23.93 a	126.82 b	24.48 a	25.96 a	3.33 b	6.90 a	10.23	32.75 b
$\overline{S}_x$	1.13	0.139	0.087	0.178	1.08	0.142	0.203	0.034	0.062	0.155	0.344
Level of sig.	**	**	**	**	**	**	**	**	**	NS	**
CV (%)	3.28	6.38	4.40	2.93	3.15	3.09	3.18	3.75	3.56	5.86	3.87

Table 2. Effect of plant spacing on yield contributing descriptors and yield of rice plant

Spacing (cm × cm)	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Length of panicle (cm)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Biological yield (t ha^{-1})	Harvest index (%)
25×15	135.8 a	8.13 bc	7.54 b	24.13	17.46 b	24.78	10.16 b	35.28 a
25×10	135.3 a	7.50 c	6.88 c	23.31	17.32 b	24.67	11.18 a	32.18 b
20×15	137.5 a	8.55 b	7.80 b	23.70	18.74 a	24.57	10.43 b	35.65 a
20×10	129.0 b	8.63 b	7.83 b	23.07	18.51 a	24.72	10.15 b	35.03 a
15×15	128.7 b	9.46 a	8.42 a	23.70	16.90 b	24.68	9.176 c	34.09 a
$\overline{S}_x$	1.78	0.220	0.138	0.282	0.225	0.321	0.244	0.543
Level of sig.	**	**	**	NS	**	NS	**	**
CV (%)	3.28	6.38	4.40	2.93	3.09	3.18	5.86	3.87

Table 3. Effect of cultivar and plant spacing interaction on yield contributing descriptors and yield of rice plant

Interaction (cultivar × spacing)	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Length of panicle (cm)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Biological yield (t ha^{-1})	Harvest index (%)
$V_1 \times S_1$	116.30 d	8.67 cd	8.00 b	24.10	10.57 d	23.47	10.87 ab	34.59 bc
$V_1 \times S_2$	109.40 de	10.17 ab	9.42 a	23.50	11.02 d	23.10	9.81 bcd	39.56 a
$V_1 \times S_3$	107.10 e	8.75 cd	8.00 b	22.83	10.23 d	23.07	11.13 a	36.93 b
$V_1 \times S_4$	109.90 de	9.25 bc	8.33 b	22.35	13.25 c	24.20	10.36 abc	34.61 bc
$V_1 \times S_5$	111.70 de	10.25 a	8.92 a	23.37	10.38 d	23.17	8.82 d	35.04 bc
$V_2 \times S_1$	155.30 b	7.58 ef	7.08 c	24.17	24.35 b	26.10	9.45 cd	35.98 b
$V_2 \times S_2$	163.60 a	6.25 g	5.75 d	23.78	24.40 b	26.27	11.23 a	27.43 e
$V_2 \times S_3$	165.70 a	6.92 fg	6.17 d	23.90	26.47 a	26.03	11.05 a	31.74 d
$V_2 \times S_4$	148.00 bc	8.00 de	7.33 c	23.78	23.78 b	25.23	9.93 bcd	35.45 bc
$V_2 \times S_5$	145.80 c	8.67 cd	7.92 b	24.03	23.42 b	26.20	9.53 cd	33.14 cd
$\overline{S}_x$	2.53	0.311	0.196	0.399	0.318	0.453	0.346	0.768
Level of sig.	**	**	**	NS	**	NS	**	**
CV (%)	3.28	6.38	4.40	2.93	3.09	3.18	5.86	3.87

V_1 = BRRI dhan49, V_2 = Double grained rice cultivar

S_1 = 25 cm × 15 cm, S_2 = 25 cm × 10 cm, S_3 =20 cm × 15 cm, S_4 =20 cm × 10 cm, S_5 =15 cm × 15 cm.

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)

** =Significant at 1% level of probability, NS = Non-significant.

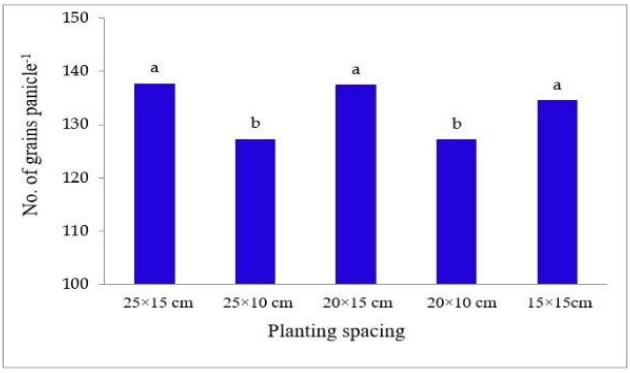

Figure 1. Effect of planting spacing on the number of grains panicle^{-1}

Figure 2. Effect of planting spacing on the grain yield (t ha^{-1})

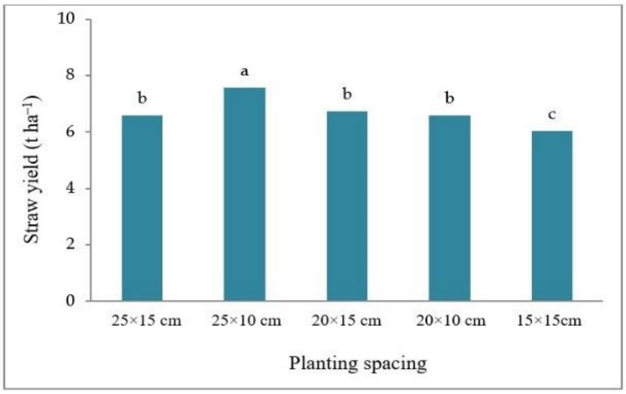

Figure 3. Effect of planting spacing on the straw yield (t ha^{-1})

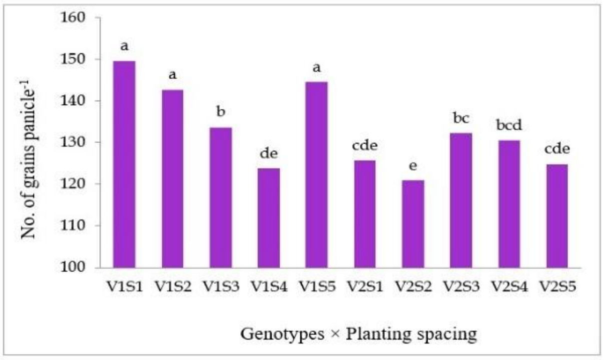

Figure 4. Effect of interaction of genotype with planting spacing on the grain yield (t ha^{-1})

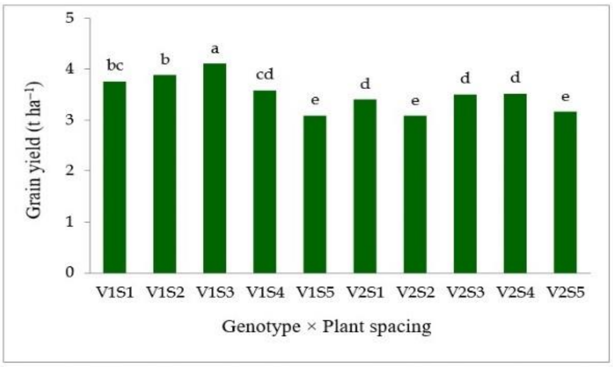

Figure 5. Effect of interaction of genotype with planting spacing on the grain yield (t ha^{-1})

V_1 = BRRI dhan49, V_2 = Double grained rice cultivar.
S_1 = 25 cm × 15 cm, S_2 = 25 cm × 10 cm, S_3 =20 cm × 15 cm, S_4 =20 cm × 10 cm, S_5 =15 cm × 15 cm.

Interaction effect

Interaction effect of genotype and plant spacing had a significant impact on yield and yield contributing descriptors of the double grained rice cultivar and BRRI dhan49 except for panicle length and 1000-grain weight (Table 3). The double grained rice cultivar planted at 20 cm × 15 cm spacing gave the tallest plant (165.70 cm) which was statistically similar to the plant height (163.60 cm) of double grained rice cultivar with 25 cm × 10 cm spacing. It was observed that the double grained rice cultivar produced relatively taller plant stature than BRRI dhan49 in all spacing combinations (Table 3). Sarwar and Chanda (2018) and Sarwar et al. (2020) also reported that the double grained rice cultivar had produced relatively taller plants. The tiller production behaviour of BRRI dhan49 was found better than the double grained rice cultivar in interaction with plant spacing. The highest total tillers hill^{-1} (10.25) and was found in BRRI dhan49 with 15 cm × 15 cm and the lowest total tillers hill^{-1} (6.25) was found in double grained rice cultivar with 25 cm × 10 cm. The highest effective tillers hill^{-1} (9.42) was recorded in BRRI dhan49 with 25 cm × 10 cm which was at par with that of BRRI dhan49 with 15 cm × 15 cm. The lowest effective tillers hill^{-1} was observed in the double grained rice cultivar with the interaction of 25 cm × 10 cm and 20 cm × 15 cm, respectively. Although the highest grains panicle^{-1} was found in BRRI dhan49 in interaction with 25 cm × 15 cm, 15 cm × 15 cm and 25 cm × 10 cm, respectively, the double grained rice cultivar planted at 20 cm × 15 cm performed better (132.2) than other plant spacings (Figure 4). The interaction of double grained rice cultivar with all plant spacings had more sterile spikelets panicle^{-1} than BRRI dhan49 (Table 3). Being a high yielding cultivar, BRRI dhan49 produced the highest grain yield (4.11 t ha^{-1}) with a spacing of 20 cm × 15 cm (Figure 5). The double grained rice cultivar produced a higher grain yield (3.52 t ha^{-1}) in interaction with 20 cm × 10 cm which was statistically similar to the interaction with 20 cm × 15 cm and 25 cm × 15 cm, respectively. The lowest yield (3.08 t ha^{-1}) was found in the interaction of double grained rice with 25 cm × 10 cm. The higher grain yield could be the cumulative effect of better performance of the yield contributing descriptors i.e. grains panicle^{-1} of double grained rice cultivar. Besides, the closer spacing within the line accommodated more hills per unit area thereby increasing the grain yield was also reported elsewhere (Verma et al., 2002; Paul et al., 2017; Halder et al., 2018; Saha et al., 2020). The highest straw yield (8.15 t ha^{-1}) and biological yield (11.23 t ha^{-1}) were recorded in the double grained rice cultivar with the spacing of 25 cm × 10 cm. The taller stature of double grained rice cultivar with proper spacing might be responsible for the production of the highest straw yield. The lowest straw yield (5.73 t ha^{-1}) was found in BRRI dhan49 with the spacing of 15 cm × 15 cm which was statistically identical with that of BRRI dhan49 with 25 cm × 10 cm. Statistically, along with the higher grain yield (3.51 t ha^{-1}), one of the highest biological yields (11.05 t ha^{-1}) was found at double grained rice with a spacing of 20 cm × 15 cm. However, the highest harvest index (39.56%) and the lowest (31.74%) were recorded at the interaction of 20 cm × 15 cm spacing with BRRI dhan49 and double grained rice cultivar, respectively.

The double grained rice cultivar when planted at 20 cm × 15 cm spacing produced the tallest plants, higher number of grains panicle^{-1}, higher grain yield and the highest biological yield. Therefore, the double grained rice cultivar transplanted at the spacing of 20 cm × 15 cm appeared as an improved practice in terms of grain yield performance of local transplant *Aman* rice.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper

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