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RESEARCH ARTICLE

INFLUENCE OF SPACING OF PLANTING ON THE YIELD PERFORMANCE OF SOME AROMATIC RICE VARIETIES IN *BORO* SEASON

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ABSTRACT

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University during November 2016 to June 2017 to investigate the effect of spacing of planting on the yield performance of some aromatic rice varieties in *Boro* season. The experiment comprised three varieties *viz.* BRRI dhan50, Basmati and BRRI dhan63, six spacing of planting *viz.* 25 cm × 20 cm, 25 cm × 15 cm, 20 cm × 20 cm, 20 cm × 15 cm, 15 cm × 15 cm and 20 cm × 10 cm. The experiment was laid out in a randomized complete block design with three replications. The highest grain yield (4.01 t ha^{-1}) and harvest index (47.38 %) were recorded in BRRI dhan50 followed by BRRI dhan63 while the lowest grain (3.44 t ha^{-1}) and highest straw (5.11 t ha^{-1}) yields were recorded in Basmati. Planting spacing 20 cm × 10 cm gave the highest grain (4.54 t ha^{-1}) and straw (5.92 t ha^{-1}) yields compared to other spacing. BRRI dhan50 along with 20 cm × 10 cm spacing produced the highest grain yield (5.08 t ha^{-1}) while the highest straw yield (6.71 t ha^{-1}) was recorded in Basmati at 20 cm × 10 cm plant spacing. Based on the present study it can be concluded that BRRI dhan50 along with 20 cm × 10 cm spacing of planting appears as the promising combination for higher grain yield in *Boro* season.

KEYWORDS

Aromatic rice, spacing, yield, *Boro* season.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important human food crop in the world that satisfying global hunger. The geographical, climatic and edaphic conditions of Bangladesh are favorable for year-round rice cultivation. The area and production of total rice in Bangladesh is about 11.38 million hectares and 34.71 million tons, respectively (Bangladesh Bureau of Statistics, 2017). The average production of rice is approximately 3.05 t ha^{-1} which is nearly 50% less than the world average yield (Bangladesh Bureau of Statistics, 2017). More than four thousand landraces of rice are adopted in different parts of Bangladesh having some of these are unique for quality traits including fineness, aroma, taste and protein contents (Kaul et al., 1982; Hossain et al., 2008). The yield of fine aromatic rice is lower than that of coarse and medium rice varieties in Bangladesh. Aromatic fine rice is popular in Bangladesh and other countries due to its flavor, texture and versatile uses. Aromatic rice has great potential to attract rice consumer and high price to boost up the economic condition of the rice grower in the developing countries like Bangladesh. The market price of aromatic fine rice is rapidly increasing compare to non-aromatic ones in the domestic and international market. Now-a-days demand of fine aromatic rice is increased to a great extent for both internal consumption and export (Das and Baqui, 2000). Most of the aromatic rice varieties in Bangladesh are the traditional type, photoperiod sensitive, and are grown during transplanted *Aman* season in the rainfed lowland ecosystem (Islam et al., 1996). The adequate effort has not been made yet by the researchers to find out suitable management practices of aromatic fine rice for the irrigated ecosystem in *Boro* season. Therefore, effort should be made to improve the productivity of aromatic fine rice through agronomic manipulation with suitable cultivars for the irrigated ecosystem in *Boro* season.

Plant spacing is one of the crop management activities which govern all of the components of plant need for their growth and yield. Plant spacing directly affects normal physiological activities through intra-species competition (Halder et al., 2018). Different crops and even different cultivars of a crop respond physiologically differently to plant spacing due to their differential requirement of natural resources (light, water, oxygen, carbon dioxide, nutrients) (Oad et al., 2001). Optimum plant spacing ensures optimum number of plants per unit area which lead to proper growth, yield components and ultimately grain yield. Optimum plant spacing helps plants to grow well, using more solar radiation and soil nutrients (Bhownmilk et al., 2012; Paul et al., 2017). If planting density exceeds the optimum level, competition among the plants for light and nutrients becomes severe. Ultimately, the growth of rice plants hamper with weaker and thinner tillers and the grain yield reduces. On the other hand, wider spacing can produce more bearing tillers $hill^{-1}$ by utilizing sufficient natural resources but reduces the lower number of bearing tillers per unit area which also reduces grain yield. Therefore, proper manipulation of planting spacing may lead to an increase in the economic yield of aromatic rice in *Boro* rice. So, the present study was undertaken to find out the influence of spacing of planting on the performance of aromatic rice in *Boro* season.

2. MATERIALS AND METHODS

2.1 Experimental Duration, Site and Soil

The research work was conducted at the Agronomy Field laboratory, Bangladesh Agricultural University, Mymensingh, during November 2016 to May 2017. Geographically the experimental site is located at 24°75' N latitude and 90°50' E longitude at an elevation of 18 m above the sea level.

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The site belongs to the non-calcareous dark gray floodplain soil under the Old Brahmaputra Floodplain Agro-ecological Zone (AEZ 9) (UNDP, FAO, 1988). The land was medium high with silty-loam texture. The soil of the experimental field was more or less neutral in reaction (pH 6.8), low in organic matter content (1.29%) and the general fertility level was moderate.

2.2 Experimental design and treatment details

The experiment comprised three varieties *viz.* BRRI dhan50 (V_1), Basmati (V_2), and BRRI dhan63 (V_3), and five spacing of planting *viz.* 25 cm × 20 cm (S_1), 25 cm × 15 cm (S_2), 20 cm × 20 cm (S_3), 20 cm × 15 cm (S_4), 15 cm × 15 cm (S_5) and 20 cm × 10 cm (S_6). The experiment was laid out in a Randomized Complete Block Design with three replications. Each block was divided into 18-unit plots where 18 treatment combinations were allocated at random. The unit plot size was 5.0 m^2 (2.5 m × 2.0 m). The space between plots and replications were 0.5 m and 1m, respectively. Thirty five-day old seedlings were transplanted on 21 December 2017 in the well puddled plot at the rate of three seedlings $hill^{-1}$ maintaining spacing as per experimental treatments.

2.3 Fertilizer Application

The field was fertilized with urea, triple super phosphate (TSP), muriate of potash (MoP) gypsum and zinc sulphate as the source of nitrogen, phosphorus, potassium, sulphur and zinc @ 250, 126, 120, 100, 10 kg ha^{-1}, respectively. The entire amounts of TSP, MoP, gypsum and zinc sulphate were applied during final land preparation. Urea was applied as top dressing in three equal splits at 15, 30 and 45 days after transplanting (DAT).

2.4 Transplantation of seedlings and data collection

The nursery beds were made wet by application of water one day ahead of uprooting the seedlings. Thirty five-day old seedlings were uprooted carefully without causing any mechanical injury to the root. Healthy seedlings were transplanted in the well puddled experimental plots on 21 December 2016 at the rate of three seedlings $hill^{-1}$ maintaining spacing as per experimental treatments. Different intercultural operation such as gap filling, weeding, irrigation and drainage were done for ensuring and maintaining normal growth of the crop when necessary. The crop was harvested at full maturity when 90% of the grains became golden yellow in color. Prior to harvest five hills (excluding border rows and central 1 m^2 area) were selected randomly from each unit plot and uprooted for recording data on crop characters and yield components. After sampling, the central 1.0 m × 1.0 m area was harvested to record data on grain and straw yields. BRRI dhan63 was harvested on 23 April, 2017 on the other hand BRRI dhan50 and Basmati were harvested on 30 April 2017. The harvested crops of each plot was separately bundled, properly tagged and threshed properly. The grains were cleaned and sun dried to 14% moisture content. Straws were also dried properly. Finally grain and straw yields $plot^{-1}$ were recorded and converted to t ha^{-1}. Harvest index (%) was calculated with the following formula

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100.$$

2.5 Statistical analysis

Data were compiled and tabulated in proper form for statistical analysis. The recorded data were statistically analyzed to find out the significance of variation resulting from the experimental treatments. All the collected data were analyzed following the analysis of variance (ANOVA) technique and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

3. Results and Discussion

3.1 Varietal performance

Crop characters yield components and yield of aromatic fine rice were significantly influenced by variety except panicle length (Table 1 & Figure 1). The tallest plant (73.78 cm) was obtained in BRRI dhan50 which was at par with Basmati and the shortest one (65.52 cm) was recorded in BRRI dhan63. Variation of plant height might be due to the differences in their genetic make-up. A group researchers reported variable plant heights among the varieties (Jisan et al., 2014; Chowdhury et al., 2016). The highest number of total tillers m^{-2} (384.9) and effective tillers m^{-2} (343.5) were recorded in Basmati and BRRI dhan50, respectively while the lowest values of respective tillers were found in BRRI dhan63. The reduction of number of tillers in BRRI dhan63 was due to tiller mortality in the vegetative stages. The probable reason of these results might be due to different genetic makeup of these varieties which are influence by heredity. Among the varieties, Basmati produced the highest number (93.0) of grains $panicle^{-1}$ which was as good as BRRI dhan50 (91.67) and the lowest one (91.17) was recorded in BRRI dhan63 which is statistically identical with BRRI dhan50.

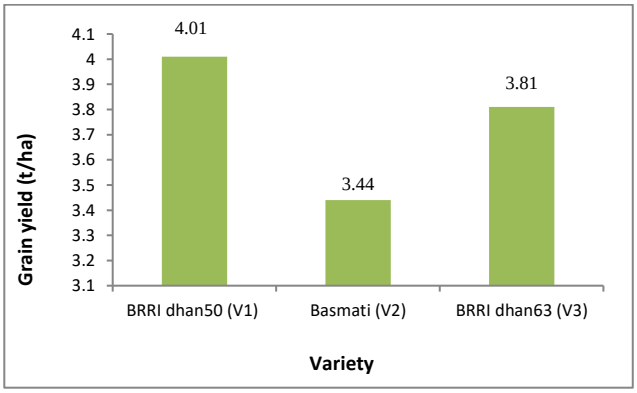

Figure 1: Effect of variety on the grain yield of aromatic rice in Boro season

Number of grains $panicle^{-1}$ differed significantly due to variety was reported elsewhere (Jisan et al., 2014; Chowdhury et al., 2016; Islam et al., 2013). In case of sterile spikelets $panicle^{-1}$, the opposite trend of grains $panicle^{-1}$was observed where the highest number of sterile spikelets $panicle^{-1}$ (15.44) was obtained in BRRI dhan63 while the lowest one (12.50) was produced in Basmati which was at par with BRRI dhan50. A group researchers showed variable number of sterile spikelets $panicle^{-1}$ among varieties (Chowdhury et al., 2016; Tyeb et al., 2013). The highest 1000-grain weight (21.58 g) was obtained in BRRI dhan50 which was statistically identical to the BRRI dhan63 and the lowest 1000-grain weight (18.78 g) was obtained in Basmati. This confirms the report who reported the variable effect of variety on 1000-seed weight (Islam et al., 2013; Sarker et al., 2014).

Table 1: Effect of variety on crop characters, yield components and yield of some aromatic rice varieties in Boro season

Variety	Plant height (cm)	Total tillers m^{-2}(no.)	Effective tillers m^{-2}(no.)	Panicle length (cm)	Grains $panicle^{-1}$ (no.)	Sterile spikelets $panicle^{-1}$ (no.)	1000-grain weight (g)	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
BRRI dhan50 (V_1)	73.78a	365.9b	343.5a	20.23	91.67ab	12.78b	21.58a	4.44b	8.45ab	47.38a
Basmati (V_2)	72.43a	384.9a	324.1b	19.89	93.00a	12.50b	18.78b	5.11a	8.56a	40.45c
BRRI dhan63 (V_3)	65.52b	309.2c	266.1c	19.95	91.17b	15.44a	21.54a	4.46b	8.26b	45.96b
Level of significance	**	**	**	NS	*	**	**	**	*	**
CV (%)	4.21	3.89	3.53	2.24	2.30	5.34	4.67	5.61	3.99	4.50

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, * =Significant at 5% level of probability, NS = Not significant

BRRI dhan50 gave the highest grain yield (4.01 t ha^{-1}) followed by BRRI dhan63 and the lowest grain yield (3.44 t ha^{-1}) was recorded in Basmati (Figure 1). Straw yield showed opposite trend for grain yield where the highest (5.11 t ha^{-1}) and lowest (4.44 t ha^{-1}) straw yield was obtained in Basmati and BRRI dhan50, respectively. The highest grain yield in BRRI dhan50 was mostly the outcome of the highest number of effective tillers m^{-2} and heavier seeds while highest straw yield in Basmati was outcome of maximum total tillers m^{-2}. Grain and straw yields differences might be due to genetic make-up of the varieties. Grain yield differed due to varietal differences was reported elsewhere (Halder et al., 2018; Jisan et al., 2014; Adhikari et al., 2018). The highest (8.56 t ha^{-1}) and lowest biological (8.26 t ha^{-1}) yield were recorded in Basmati and BRRI dhan63, respectively while the highest harvest index (47.38%) was obtained in BRRI dhan50 and the lowest one from Basmati (Table 1).

3.2 Effect of spacing

Results of the experiment showed that plant spacing had significant effect on plant height, number of total tillers m^{-2}, number of effective tillers m^{-2}, panicle length, no. of grains panicle^{-1}, grain yield, straw yield and biological yield (Table 2 and Figure 2). The tallest plant (73.73 cm) was obtained from the spacing of 25 cm × 20 cm which was at par 25 cm × 15 cm whereas the shortest plant (68.51 cm) was observed in 20 cm × 15 cm spacing which was at par with other spacing. The highest number of total tillers m^{-2} (516.7) and effective tillers m^{-2} (450.0) were obtained at closest spacing (20 cm × 10 cm) followed by the spacing 15 cm × 15 cm while the lowest values was recorded in wider spacing of 25 cm × 20 cm. Closer spacing covers maximum number of hills per unit area consequently produces maximum tillers (Paul et al., 2017; Verma et al., 2002).

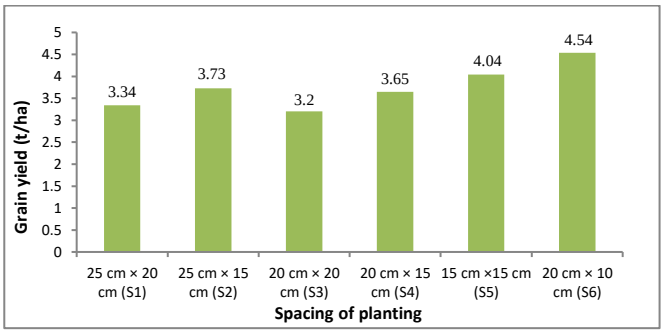

Figure 2: Effect of spacing of planting on the grain yield of aromatic rice in Boro season

The longest panicle (20.54 cm) and highest number of grains panicle^{-1} (95.44) was produced from the spacing 15 cm × 15 cm which was statistically higher from other spacing while the sterile spikelets panicle^{-1} and 1000-grain weight did not show any significant variation among the spacing. The highest grain yield (4.54 t ha^{-1}) (Figure 2), straw yield (5.92 t ha^{-1}) and biological yield (10.46 t ha^{-1}) was obtained from 20 cm × 10 cm spacing followed by the spacing 15 cm × 15 cm while the lowest corresponding values were found in 20 cm × 20 cm (Table 2). The closest spacing 20 cm × 10 cm showed the best yield (Figure 2) than other five plant densities due to highest plant population per unit area. It might be due to the fact that the closer row spacing provided highest grain yield and straw yield which resulted in the highest biological yield (Paul et al., 2017; Halder et al., 2018).

Table 2: Effect of spacing of planting on crop characters, yield components and yield of some aromatic rice varieties in Boro season

Spacing of planting	Plant height (cm)	Total tillers m^{-2}(no.)	Effective tillers m^{-2}(no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
25 cm × 20 cm (S_1)	73.73a	245.7f	218.9f	19.95b	92.00bc	13.67	20.68	4.14d	7.48d	45.08
25 cm × 15 cm (S_2)	72.11ab	294.0d	267.0d	19.93b	90.89bc	13.33	20.57	4.52c	8.25c	45.47
20 cm × 20 cm (S_3)	70.64bc	275.0e	241.7e	19.93b	92.67b	14.00	20.61	4.12d	7.32d	44.06
20 cm × 15 cm (S_4)	68.51c	358.9c	309.8c	19.88b	89.89c	13.67	20.57	4.36cd	8.01c	45.53
15 cm ×15 cm (S_5)	68.82c	430.0b	380.0b	20.54a	95.44a	13.22	20.70	4.96b	9.007b	44.94
20 cm × 10 cm (S_6)	69.65bc	516.7a	450.0a	19.91b	90.78bc	13.56	20.68	5.92a	10.46a	43.58
Level of significance	**	**	**	*	**	NS	NS	**	**	NS
CV (%)	4.21	3.89	3.53	2.24	2.30	5.34	4.67	5.61	3.99	4.50

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, * =Significant at 5% level of probability, NS = Not significant

3.3 Interaction effect of variety and spacing

The interaction between variety and spacing exert significant effect on number of total tillers m^{-2}, number of effective tillers m^{-2}, panicle length (cm), number of sterile spikelets panicle^{-1}, number of grains panicle^{-1}, grain yield, straw yield and biological yield (Table 3 and Figure 3). Numerically the tallest plant (76.73 cm) was found in BRRI dhan50 with 25 cm × 15 cm spacing and the shortest one (63.80 cm) was found in BRRI dhan63 at 15 cm × 15 cm spacing. Similar result was reported by who also observed insignificant influence of interaction between variety and spacing on plant height (Akando, 2007). The maximum number of total tillers m^{-2} (533.3) was produced in Basmati with spacing 20 cm × 10 cm and the lowest number of total tillers m^{-2} (180.0) was produced in the combination of BRRI dhan63 with spacing 25 cm × 20 cm. The highest number of effective tillers m^{-2} (466.7) was recorded with the interaction of BRRI dhan50 and 20 cm × 10 cm spacing and the lowest number of effective tillers m^{-2} (153.3) was observed in interaction of BRRI dhan63 with wider spacing 25 cm × 20 cm.

The longest panicle length (21.70 cm) and grains panicle^{-1} (100.7) were found in BRRI dhan50 with 15 cm × 15 cm and Basmati with the spacing of 15 cm × 15 cm, respectively which was statistically higher than other combinations. The highest (16.33) and lowest (11.33) number of sterile spikelets panicle^{-1} was obtained in variety BRRI dhan63 at 20 cm × 10 cm plant spacing and Basmati with 20 cm × 10 cm plant spacing, respectively. Test weight of grain differs due to treatment combination. The heaviest 1000-grain (21.73g) was obtained in BRRI dhan50 with 20 cm × 10 cm and lightest one was obtained in Basmati with 20 cm × 20 cm plant spacing. The highest grain yield (5.08 t ha^{-1}) was found in interaction effect between BRRI dhan50 and spacing 20 cm × 10 cm followed by BRRI dhan63 with spacing 20 cm × 10 cm and the lowest grain yield (2.97 t ha^{-1}) was found in the interaction effect between Basmati and spacing 20 cm × 20 cm (Figure 3). The result clearly indicates that population density of some aromatic rice varieties increases in closer spacing which ultimately increase the grain yield.

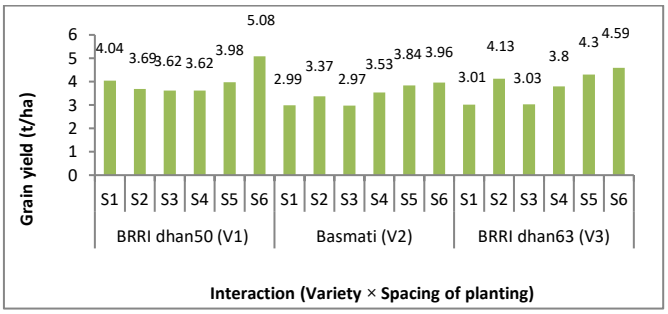

Figure 3: Effect of interaction between variety and spacing of planting on the grain yield of aromatic rice in Boro season

The highest straw yield (6.71 t ha^{-1}) was obtained in Basmati with the row spacing 20 cm × 10 cm and the lowest straw yield (3.56 t ha^{-1}) was recorded in BRRI dhan63 with the interacting row spacing of 20 cm × 20 cm (Tyeb et al., 2013; Shel et al., 2019). The highest biological yield (10.8 t ha^{-1}) was obtained in variety BRRI dhan50 with the spacing 20 cm × 10 cm which was statistically identical with the interaction of Basmati at 20 cm × 10 cm spacing and the lowest biological yield was found in BRRI dhan63 with the plant spacing of 20 cm × 20 cm. The highest harvest index (49.52 %) was found in the combination of BRRI dhan50 and spacing 25 cm × 20 cm which is statistically identical with the combination of BRRI dhan50 and spacing 25 cm × 15 cm and the lowest harvest index (37.10 %) was produced in the combination of Basmati and spacing 20 cm × 10 cm (Table 3).

Table 3: Effect of interaction between variety and spacing of planting on crop characters, yield components and yield of some aromatic rice varieties in Boro season

Interaction (Variety x Spacing of planting)	Plant height (cm)	Total tillers m^{-2}(no.)	Effective tillers m^{-2} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
$V_1 \times S_1$	76.67	290.3fg	246.7i	19.95b	90.33bc	13.33de	21.53	4.13hi	8.17fgh	49.52a
$V_1 \times S_2$	76.73	306.0f	306.0f	19.97b	91.33bc	12.67def	21.53	3.85ij	7.54hi	48.55a
$V_1 \times S_3$	72.87	275.0gh	266.7gh	20.03b	93.67b	13.67cd	21.53	4.06hi	7.68hi	47.14ab
$V_1 \times S_4$	70.73	419.3d	340.0e	19.81b	91.00bc	12.00ef	21.50	4.21ghi	7.83gh	46.12ab
$V_1 \times S_5$	70.60	405.0d	435.0b	21.70a	93.33b	12.00ef	21.63	4.64efg	8.62def	46.15ab
$V_1 \times S_6$	75.07	500.0bc	466.7a	19.93 b	90.33bc	13.00de	21.73	5.78b	10.8a	46.78ab
$V_2 \times S_1$	76.20	266.7ghi	256.7hi	19.87b	93.00b	12.33def	19.00	4.21ghi	7.19i	41.52cd
$V_2 \times S_2$	75.13	333.0e	279.0g	19.76b	91.33bc	12.67def	18.70	5.04de	8.41efg	40.07de
$V_2 \times S_3$	72.33	300.0f	241.7i	20.04b	91.67bc	13.33de	18.67	4.74ef	7.71hi	38.77de
$V_2 \times S_4$	70.93	396.7d	374.0c	19.77b	90.00bc	13.00de	18.77	4.49fgh	8.02fgh	44.11bc
$V_2 \times S_5$	72.07	480.0c	360.0cd	19.84b	100.7a	12.33def	18.80	5.51bc	9.35bc	41.13cd
$V_2 \times S_6$	67.93	533.3a	433.3b	20.07b	91.33bc	11.33f	18.77	6.71a	10.6a	37.10e
$V_3 \times S_1$	68.33	180.0j	153.3k	20.04b	92.67bc	15.33ab	21.50	4.09hi	7.10ij	42.37cd
$V_3 \times S_2$	64.47	243.0i	216.0j	20.06b	90.00bc	14.67bc	21.47	4.68efg	8.81cde	46.90ab
$V_3 \times S_3$	66.73	250.0i	216.7j	19.73b	92.67bc	15.00b	21.63	3.56j	6.58j	45.97ab
$V_3 \times S_4$	63.87	260.7hi	215.3j	20.07b	88.67 c	16.00ab	21.43	4.38fgh	8.18fgh	46.45ab
$V_3 \times S_5$	63.80	405.0d	345.0de	20.08b	92.33bc	15.33ab	21.67	4.75ef	9.05cd	47.49ab
$V_3 \times S_6$	65.93	516.7ab	450.0ab	19.73b	90.67bc	16.33a	21.53	5.27cd	9.86b	46.55ab
Level of sig.	NS	**	**	**	**	**	NS	**	**	**
CV (%)	4.21	3.89	3.53	2.24	2.30	5.34	4.67	5.61	3.99	4.50

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 = Not significant

V1 = BRRI dhan50, V2 = Basmati, V3 = BRRI dhan63, S1 = 25 cm × 20 cm, S2 = 25 cm × 15 cm, S3 = 20 cm × 20 cm, S4 = 20 cm × 15 cm, S5 = 15 cm × 15 cm and S6 = 20 cm x 10 cm

4. Conclusion

Results indicate BRRI dhan50 produced the highest grain yield followed by BRRI dhan63 and Basmati. The highest grain yield and straw yield were obtained at 20 cm × 10 cm plant spacing. BRRI dhan50 along with 20 cm × 10 cm spacing produced the highest grain yield while the lowest grain yield was recorded in Basmati with 20 cm × 20 cm spacing. Based on the present study it can be concluded that aromatic rice BRRI dhan50 with the spacing of 20 cm × 10 cm seems to be a promising combination for achieving higher grain yield in *Boro* season.

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