Vol 3 No 2 June 2022 Pages 1-5 e-ISSN 2708-5694

Journal of Agriculture, Food and Environment (JAFE)

Journal Homepage: http://journal.safebd.org/index.php/jafe

http://doi.org/10.47440/JAFE.2022.3201

Original Article

Effect of Spacing on the Performance of T. *Aman* Rice Cv. *Superamandhan*

Khatun IA[1,2], Islam N[1], Perveen S[1], Rouf MA[3] and Hasan AK[1*]

[1]Department of Agronomy, Bangladesh Agricultural University, Mymensingh
[2]Department of Agricultural Extension, Sakhipur, Tangail
[3]Department of Agricultural Extension, Debidwar, Cumilla

Article History

Received: 26 March 2022

Revised: 30 April 2022

Accepted: 05 May 2022

Published online: 30 June 2022

***Corresponding Author**

Hasan AK, E-mail: akhasan@bau.edu.bd

Keywords

T. *aman* rice, planting density, Yield, Growth, *Superamandhan*

How to cite: Khatun IA, Islam N, Perveen S, Rouf MA and Hasan AK (2022). Effect of Spacing on the Performance of T. *Aman* Rice Cv. *Superamandhan*. J. Agric. Food Environ. 3(2): 1-5.

ABSTRACT

The selection of appropriate plant spacing may contribute to the yield potential of a rice cultivar. Therefore, an experiment was conducted to evaluate the effect of spacing on '*Superamandhan*' at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from July to December. Twenty hill spacings viz. 25cm × 15cm (S_1), 25 cm × 20 cm (S_2), 25cm × 25 cm (S_3), 30 cm × 20 cm (S_4), 30 cm × 25 cm (S_5), 30 cm × 30 cm (S_6), 40 cm × 20cm (S_7), 40 cm × 30 cm (S_8), 40 cm × 40 cm (S_9), 50 cm × 20 cm (S_{10}), 50 cm × 30 cm (S_{11}), 50 cm ×40 cm (S_{12}), 50 cm × 50 cm (S_{13}), 60 cm × 60 cm (S_{14}), 60 cm × 50 cm (S_{15}), 60 cm × 40 cm (S_{16}), 60 cm × 30 cm (S_{17}), 70 cm × 50 cm (S_{18}), 70 cm × 40 cm (S_{19}) and 70 cm × 30 cm (S_{20}) were included as experimental treatment. The experimental design was randomized complete block design (RCBD) with three replications. This study showed that spacing had a significant influence on the growth, yield, and yield contributing characters of *Superamandhan*. The highest yield (4.33 t ha^{-1}) of T. *aman* rice was found at 30 cm × 25 cm (S_5) spacing. So, it may conclude that '*Superamandhan*' grown under 30 cm × 25 cm spacing appeared to be the best for obtaining the highest grain yield.

Introduction

Rice (*Oryza sativa* L.) is one of the major cereals in Bangladesh which covers 89% of total cropped area of this country (BBS, 2019). Among the three rice growing seasons (*aus*, *aman*, and *boro*) of Bangladesh, *aman* rice covers about 50.56% of the total rice growing area and contributes to 44% of total rice production in the country (Sayeed and Yunus, 2018; Childs, 2020). But the average yield of T. *aman* rice is about 2.50 t ha^{-1} which is very low. The yield of T. *aman* rice may be increased through introduction of high yielding varieties and improved agronomic manipulations such as proper spacing.

The selection of appropriate plant spacing may influence the yield potential of a rice cultivar through effective utilization of solar radiation, soil moisture and nutrient uptake from the soil (Pandey *et al.*, 2021).When the planting density exceeds an optimum level, these factors may be deficient and competition among plants becomes severe. Accordingly, the plant growth slows down and the grain yield decreases. Conversely, these factors may not be properly utilized at lower planting density. Properly spacing between rows and within rows can result in the maximum benefit from a rice field.

Plant density had great influence on the tillering habit and production of grains $panicle^{-1}$ which is responsible for the variation of yield in rice. Optimum spacing ensure sufficient temperature, moisture and other soil factors that results in maximum number of total tillers m^{-2}, maximum number of fertile tillers m^{-2} (Alam, 2006). Inappropriate spacing reduces the yield up to 25–30 per cent whereas the optimum plant density ensures the plant to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients (Miah *et al.*, 1990; Salma *et al.*, 2017). It plays indirect but key role for proficient exploitation of solar radiation, absorption of necessary nutrients, well tillering, higher leaf area, etc (Mohaddesi *et al.*, 2011). In contrast, beyond the optimum level, severe competitions (for light, nutrients, and water) slow down plant growth and decrease grain yield (Bozorgi *et al.*, 2011).

Very few research works have so far been conducted with *Superamandhan*, a HYV collection in the department of agronomy, Bangladesh Agricultural University, which has been claimed to yield up to 9.0 t ha^{-1} in *aman* season. Therefore, the present study was undertaken to find out the effect of spacing on yield and yield attributes of *Superamandhan*.

Materials and Methods

Experimental Site

The experiment was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during *aman* season (June to December) to ascertain the effect of spacing on the yield of *Superamandhan*. The area belongs to the non-calcareous dark grey soil under Agro-ecological Zone of the Old Brahmaputra Floodplain (AEZ-9) located at 24° 75' N latitude and 90° 50' E longitude at an altitude of 18 meter (FAO, 1988). It was well drained medium high land with silty-loam texture and the soil was more or less neutral (pH 6.82) with low soil fertility. The site was located under the sub-tropical climate which is specialized by moderately high temperature with heavy rainfall during the kharif season (April-September) and low rainfall with moderately low temperature during rabi season (October to March).

Treatments and Design

The experiment consists of twenty hills spacing viz., 25cm × 15cm (S_1), 25cm × 20cm (S_2), 25cm × 25cm (S_3), 30cm × 20cm (S_4), 30cm × 25cm (S_5), 30cm × 30cm (S_6), 40cm × 20cm (S_7), 40cm × 30cm (S_8), 40cm × 40cm (S_9), 50cm × 20cm (S_{10}), 50 cm × 30cm (S_{11}), 50 cm × 40cm (S_{12}), 50 cm × 50cm (S_{13}), 60cm × 60cm (S_{14}), 60 cm × 50 cm (S_{15}), 60 cm × 40cm (S_{16}), 60cm × 30cm (S_{17}), 70cm × 50cm (S_{18}), 70cm × 40cm (S_{19}) and 70 cm × 30cm (S_{20}). It was laid out in Randomized Complete Block Design (RCBD) with three replications. The size of the unit plot was 10 m^2 (4.0 m ×2.5 m). The distance maintained between the unit plots and replications were 0.75 m and 2 m, respectively.

Crop Husbandry

The variety used for this experiment was '*Superamandhan*'. Seeds were collected from department of Agronomy, Bangladesh Agricultural University, Mymensingh and sown in the nursery bed on 17th June. The main field was prepared by 2-3 ploughing and cross ploughing along with removal of weeds, stubbles and crop residues and trimming ails. Seedlings were transplanted in the field on mid July. Before transplanting, the land was fertilized with urea, triple super phosphate, muriate of potash, gypsum and zinc @ 500-80-250-60-10 g $plot^{-1}$, respectively, considered as the recommended rate of fertilizer (BARC, 2012). All fertilizers and 1/3rd urea were applied during final land preparation. The rest amount of urea was applied as top dressing at 20 DAT (days after transplanting) and 45 DAT. All the cultural practices (Gap filling, irrigation, weeding, drainage and pesticide application) were done when necessary. Three weedings were done manually using *niri* at 15, 30 and 45 DAT. Plants were infested by leaf hopper, rice yellow stem borer and rice bug which were successfully controlled by spraying Diazinon and Malathion at 25 DAT. Cupravit was applied for bacterial leaf blight. Grains were harvested when about all crops reached their full maturity stage and the date of harvesting was confirmed when 90% of the seeds became golden yellow in color.

Data Collection

From each plot, three hills (excluding border hill) were randomly selected and uprooted before harvesting for recording of necessary data. The crop was harvested plot-wise and the harvested crop was brought to the threshing floor and sundried. Threshing was done by hand and then dried in the sun for three to four consecutive days for achieving safe moisture content of seed.

Statistical Analysis

Data on different parameters were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done by statistical package MSTAT-C. The mean variations among the treatments were tested with Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results

Growth Parameters at Different Growth Stages

Growth parameters like plant height and number of tillers $hill^{-1}$ were significantly influenced by different plant spacing at different growth stages (Table 1 and Figure 1). The tallest plant (71.45 cm, 91.05 cm, 102.2 cm and 129.3 cm) were obtained at the plant spacing 60 cm × 40 cm (S_{16}) at 30, 45, 60 and 75 DAT, respectively (Table 1). The shortest one (45.87 cm, 60.81 cm, 75.89 cm and 93.22 cm) were obtained at closest spacing 25 cm × 15 cm (S_1) at 30, 45, 60 and 75 DAT, respectively.

Table 1. Effect of spacing on plant height of T. *aman* rice cv. *superamandhan*.

Spacing	Plant height (cm) at different days after transplanting (DAT)			
	30	45	60	75
25 cm × 15 cm (S_1)	45.87 j	60.81 i	75.89 h	93.22 i
25 cm × 20 cm (S_2)	49.22 ij	75.87 cdefg	80.67 gh	95.59 hi
25cm × 25 cm (S_3)	50.07 hij	71.11 fgh	86.99 ef	99.11 hi
30 cm × 20 cm (S_4)	47.90 ij	67.88 h	89.11 ef	101.0 h
30 cm × 25 cm (S_5)	45.99 j	71.11 fgh	90.63 def	109.8fg
30 cm × 30 cm (S_6)	52.20 ghi	75.99 cdefg	95.77bcd	103.0 gh
40 cm × 20 cm (S_7)	60.99 de	79.33 bcde	85.29 fg	101.7 h
40 cm × 30 cm (S_8)	62.67 cd	76.55 cdefg	90.73def	122.3 abcd
40 cm × 40 cm (S_9)	51.98 ghi	72.74 defgh	79.33 h	116.0def
50 cm × 20 cm (S_{10})	61.53 de	76.66 cdefg	87.80 ef	113.0 ef
50 cm × 30 cm (S_{11})	66.13 bc	74.22 cdefgh	90.15def	119.7 bcde
50 cm × 40 cm (S_{12})	69.13 ab	80.99 bc	92.00 cde	124.1 abcd
50 cm × 50 cm(S_{13})	54.27 fgh	71.70 efgh	97.67 abc	118.2 cde
60 cm × 60 cm (S_{14})	55.85 fg	71.00 gh	91.07def	126.9 ab

Spacing	Plant height (cm) at different days after transplanting (DAT)			
	30	45	60	75
60 cm × 50 cm(S_{15})	64.80 bcd	78.33 bcdefg	88.00 ef	120.7 bcde
60 cm × 40 cm(S_{16})	71.45 a	91.05 a	102.0 a	129.3 a
60 cm × 30 cm (S_{17})	68.35 ab	80.66 bcd	98.33 ab	121.7 abcd
70 cm × 50 cm (S_{18})	61.07 de	85.77 ab	95.67 bcd	118.2 cde
70 cm × 40 cm (S_{19})	49.87 hij	73.55cdefgh	97.48 abc	126.4 abc
70 cm × 30 cm (S_{20})	57.55 ef	79.11 bcdef	92.26 cde	121.0 bcde
Level of sig.	**	**	**	**
CV (%)	4.34	5.42	3.49	3.80

** =Significant at 1% level of probability

S_1 = 25 cm x 15 cm
S_2 = 25 cm x 20 cm
S_3 = 25 cm x 25 cm
S_4 = 30 cm x 20 cm
S_5 = 30 cm x 25 cm
S_6 = 30 cm x 30 cm
S_7 = 40 cm x 20 cm
S_8 = 40 cm x 30 cm
S_9 = 40 cm x 40 cm
S_{10} = 50 cm x 20 cm
S_{11} = 50 cm x 30 cm
S_{12} = 50 cm x 40 cm
S_{13} = 50 cm x 50 cm
S_{14} = 60 cm x 60 cm
S_{15} = 60 cm x 50 cm
S_{16} = 60 cm x 40 cm
S_{17} = 60 cm x 30 cm
S_{18} = 70 cm x 50 cm
S_{19} = 70 cm x 40 cm
S_{20} = 70 cm x 30 cm

The number of tillers hill^{-1} varied due to spacing at different sampling dates (Figure 1). At 30 DAT the maximum number of tillers hill^{-1}(12.0) was found in the spacing S_1 (25 cm × 15 cm) while the minimum (7.00) was in S_9 (40 cm × 30 cm) which was statistically identical to the spacing S_7 (40 cm × 20 cm), S_{14} (60 cm × 60 cm) and S_{15} (60 cm× 50 cm) (Figure 2). At 45 DAT the highest number of tillers hill^{-1} (27.67) was observed from the spacing S_{13} (50 cm × 50 cm) and lowest number (12.0) from the spacing S_2 (25 m × 20 cm). At 60 DAT the highest number of tillers hill^{-1} (38.67) was observed from the spacing S_{13} (50 cm × 50 cm) and lowest number (14.67) from S_1 (25 m × 15 cm) (Figure 1). At 75 DAT, the maximum number of tillers hill^{-1} (35.33) was observed from the spacing S_{14} (60 cm x 60 cm) which was statistically identical to S_{18} (70 cm × 50 cm) and lowest number (8.667) from S_1 (25 m × 15 cm).

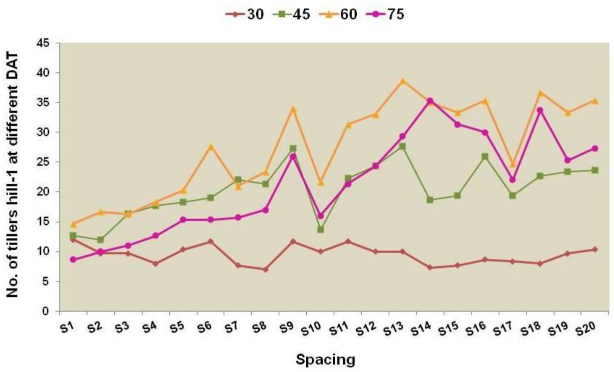

Figure 1. Effect of spacing on numbers of tillers hill^{-1} at different days after transplanting (DAT).

S_1 = 25 cm x 15 cm
S_2 = 25 cm x 20 cm
S_3 = 25 cm x 25 cm
S_4 = 30 cm x 20 cm
S_5 = 30 cm x 25 cm
S_6 = 30 cm x 30 cm
S_7 = 40 cm x 20 cm
S_8 = 40 cm x 30 cm
S_9 = 40 cm x 40 cm
S_{10} = 50 cm x 20 cm
S_{11} = 50 cm x 30 cm
S_{12} = 50 cm x 40 cm
S_{13} = 50 cm x 50 cm
S_{14} = 60 cm x 60 cm
S_{15} = 60 cm x 50 cm
S_{16} = 60 cm x 40 cm
S_{17} = 60 cm x 30 cm
S_{18} = 70 cm x 50 cm
S_{19} = 70 cm x 40 cm
S_{20} = 70 cm x 30 cm

Crop Characters, Yield and Yield attributes during Harvest

Plant spacing had significant effect on crop characters, yield and yield contributing characters of *Superamandhan* (Table 2, Figure 2 and Figure 3). The tallest plant (170.20 cm) was found at S_5 (30 cm × 25 cm) treatment and the shortest plant (152.7 cm) was at S_{14} and S_{19} (Table 1). The maximum number of total tillers hill^{-1} (31.11), effective tillers hill^{-1} (26.67) and non-effective tillers hill^{-1} (4.44) obtained from S_5 and the lowest result was found at S_{19} treatment (Figure 2).

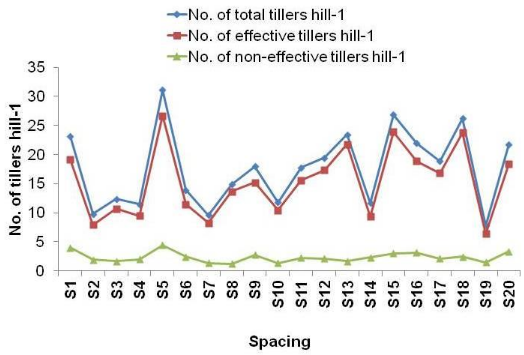

Figure 2. Effect of spacing on numbers of total tillers hill^{-1}, no. of effective tillers hill^{-1} and no. of non-effective tillers hill^{-1} at different days after transplanting (DAT).

S_1 = 25 cm x 15 cm
S_2 = 25 cm x 20 cm
S_3 = 25 cm x 25 cm
S_4 = 30 cm x 20 cm
S_5 = 30 cm x 25 cm
S_6 = 30 cm x 30 cm
S_7 = 40 cm x 20 cm
S_8 = 40 cm x 30 cm
S_9 = 40 cm x 40 cm
S_{10} = 50 cm x 20 cm
S_{11} = 50 cm x 30 cm
S_{12} = 50 cm x 40 cm
S_{13} = 50 cm x 50 cm
S_{14} = 60 cm x 60 cm
S_{15} = 60 cm x 50 cm
S_{16} = 60 cm x 40 cm
S_{17} = 60 cm x 30 cm
S_{18} = 70 cm x 50 cm
S_{19} = 70 cm x 40 cm
S_{20} = 70 cm x 30 cm

The tallest panicle (25.60 cm) was observed at S_5 and the shortest panicle (22.53 cm) at S_{19} (Table 2). The maximum number of grains panicle^{-1} (174.0) was found from S_5 which was statistically identical to the spacing S_{13} and S_{18}. The lowest number of grains panicle^{-1} (101.0) produced in the widest spacing 70 cm ×40 cm (S_{19}). Maximum sterile spikelet's panicle^{-1} (37.67) showed at S_{19} and the lowest (16.33) from S_3 and S_{17} spacing. The weight of 1000 grains was not significantly affected by spacing (Table 2).

Table 2. Effect of spacing on yield and yield contributing characters of *T. aman* rice cv. super *aman* dhan.

Spacing	Plant height (cm)	Panicle length (cm)	Grains panicle^{-1} (no.)	No. of sterile spikelets panicle^{-1}	1000 grain weight (g)	Biological yield (t ha^{-1})	Harvest index (%)
S_1	160.4 bcd	23.30bc	106.0cd	26.33de	28.70	8.36cd	43.44ab
S_2	161.4abcd	24.51abc	114.3cd	27.67cd	28.93	7.46def	42.06ab
S_3	161.9abcd	23.11 bc	110.9cd	16.33ij	28.90	8.41cd	43.75a
S_4	163.1abc	23.40 bc	107.7cd	14.33jk	28.80	8.13cde	43.55ab
S_5	170.20a	25.60a	174.0 a	13.67k	29.44	11.0a	39.41 c
S_6	163.7ab	23.00 bc	109.7cd	21.00fg	28.77	9.71 b	41.10bc
S_7	162.6abc	23.67abc	115.3cd	25.33e	28.60	8.51cd	42.81ab
S_8	161.8abcd	23.87abc	116.7cd	33.00b	28.87	8.18 cde	41.33abc
S_9	162.6abc	23.73abc	131.0bc	21.00fg	28.95	9.55 b	42.89ab
S_{10}	159.5 bcd	24.13abc	122.3cd	19.67gh	28.60	7.85cdef	42.66ab
S_{11}	153.8 cd	23.27 bc	113.3cd	22.00fg	28.49	8.06cde	42.30ab
S_{12}	158.2 bcd	24.93ab	149.7 ab	29.00c	28.94	8.78bc	43.28ab
S_{13}	164.3ab	24.93ab	159.3 a	23.00f	28.32	8.19cde	41.86ab
S_{14}	152.7 d	25.00ab	152.3 ab	27.33cde	28.65	8.06cde	42.28ab
S_{15}	159.8 bcd	25.13ab	147.3 ab	32.00b	29.28	8.09cde	42.33ab
S_{16}	154.0 cd	25.00ab	150.7 ab	20.67g	28.97	7.85cdef	42.89ab
S_{17}	164.4ab	24.00abc	154.0 ab	16.33ij	29.12	9.58 b	41.06 bc
S_{18}	152.4 d	25.13ab	169.0 a	20.33gh	28.71	7.21ef	42.31ab
S_{19}	152.7 d	22.53c	101.0 d	37.67a	28.21	6.94 f	43.09ab
S_{20}	166.1ab	25.17ab	154.7 ab	18.33hi	29.05	8.26cde	41.09 bc
Level of sig.	**	*	**	**	NS	**	*
CV (%)	3.06	4.52	10.61	5.39	2.41	6.82	3.11

** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Not significant

S_1 = 25 cm x 15 cm	**S_5** = 30 cm x 25 cm	**S_9** = 40 cm x 40 cm	**S_{13}** = 50 cm x 50 cm	**S_{17}** = 60 cm x 30 cm
S_2 = 25 cm x 20 cm	**S_6** = 30 cm x 30 cm	**S_{10}** = 50 cm x 20 cm	**S_{14}** = 60 cm x 60 cm	**S_{18}** = 70 cm x 50 cm
S_3 = 25 cm x 25 cm	**S_7** = 40 cm x 20 cm	**S_{11}** = 50 cm x 30 cm	**S_{15}** = 60 cm x 50 cm	**S_{19}** = 70 cm x 40 cm
S_4 = 30 cm x 20 cm	**S_8** = 40 cm x 30 cm	**S_{12}** = 50 cm x 40 cm	**S_{16}** = 60 cm x 40 cm	**S_{20}** = 70 cm x 30 cm

Superamandhan yield was significantly affected by different spacing (Figure 3). The highest grain yield (4.33t ha^{-1}) was found from S_5 treatment and the lowest yield (3.00 t ha^{-1}) at S_{19} spacing which was statistically identical to the spacing S_1, S_2, S_{18}, and S_{19} (Figure 3). The highest straw yield (6.66 t ha^{-1}) was observed from 30 cm × 25 cm (S_5) and the lowest result (3.94 t ha^{-1}) from 70 cm × 40 cm (S_{19}) spacing (Figure 3).

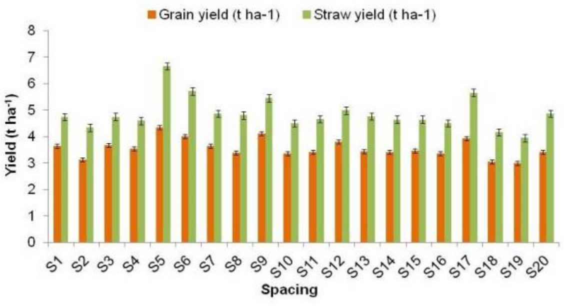

Figure 3. Effect of spacing on grain and straw yields of T. *aman* rice.

S_1 = 25 cm x 15 cm	**S_8** = 40 cm x 30 cm	**S_{15}** = 60 cm x 50 cm
S_2 = 25 cm x 20 cm	**S_9** = 40 cm x 40 cm	**S_{16}** = 60 cm x 40 cm
S_3 = 25 cm x 25 cm	**S_{10}** = 50 cm x 20 cm	**S_{17}** = 60 cm x 30 cm
S_4 = 30 cm x 20 cm	**S_{11}** = 50 cm x 30 cm	**S_{18}** = 70 cm x 50 cm
S_5 = 30 cm x 25 cm	**S_{12}** = 50 cm x 40 cm	**S_{19}** = 70 cm x 40 cm
S_6 = 30 cm x 30 cm	**S_{13}** = 50 cm x 50 cm	**S_{20}** = 70 cm x 30 cm
S_7 = 40 cm x 20 cm	**S_{14}** = 60 cm x 60 cm	

The highest biological yield (11 t ha^{-1}) was recorded from S_5 which differed significantly from other spacing and the lowest biological yield (6.94 t ha^{-1}) was obtained from the widest spacing S_{19}. The highest harvest index (43.75%) was obtained from (S_3) 25cm × 25cm spacing and the lowest one (39.41 %) was obtained from (S_5) 30cm × 25 cm (Table 2).

Discussion

Different plant spacing had significant influence on plant growth, yield and yield contributing characters might be due to availability of light, air and absorption of nutrient. Bhowmik *et al.* (2012) reported that wider spacing produced the highest plant height. Similar results were also obtained by Haque (2011) and Roy *et al.* (2017), they found that wider hill spacing produced the tallest plant than closer hill spacing. Wider spaced plants received more nutrient, moisture and light which resulted in more tiller hill^{-1}. The result revealed that 30 cm × 25 cm spacing had the greatest opportunity to produce more number of effective tillers hill^{-1}. It might be due to the fact that the spacing provided enough nutrients, light and air which played vital role in producing more effective tillers hill^{-1}. Similar findings were reported by Rasool *et al.*, (2013); Mobasser *et al.*, (2007).

Closer spacing produced higher number of grains panicle^{-1} than wider spacing. The number of sterile spikelet's panicle^{-1} increased with increasing spacing. This result collaborates to the findings of Verma *et al.* (2002) and Rautary *et al.* (2007). Spacing had no significant effect on 1000 grain weight may due to genetic character (Laila *et al.*, 2020). The yield of *Superamandhan* increased with decreasing spacing due to more number of effective tillers hill^{-1} and higher number of grains panicle^{-1}. Mahato *et al.* (2007), Uddin *et al.* (2010) and Bozorgi *et al.* (2011) also stated that grain yield of rice under closer spacing's was significantly higher than wider spacing's.

Conclusion

The present study showed that spacing had a profound effect on *Superamandhan*. At 30 cm × 25 cm plant spacing, this variety gives the best performance regarding growth, yield, and yield contributing characters. So, 30 cm × 25 cm spacing may be recommended to the farmer's level to obtain the highest grain yield from the variety '*Superamandhan*'.

References

Alam F (2006). Effect of spacing, number of seedlings hill-1 and fertilizer management on the performance of Boro rice cv. BRRI dhan29. MS Thesis, Dept. Agron., Bangladesh Agril. Univ., Mymensingh. pp. 24-27.

BBS (Bangladesh Bureau of Statistics) (2019). Statistical Year Book of Bangladesh, Bureau of Statistics Division, Ministry of Plan, Government People's Republic of Bangladesh, Dhaka. pp. 140-144.

BARC (2012). Fertilizer Recommendation Guide (FRG). Bangladesh Agricultural Research Council, Dhaka.

Bozorgi HR, Faraji A and Danesh RK (2011). Effect of plant density on yield and yield components of rice. World Appl. Sci. J. 12:2053–2057.

Bhowmik SK, Sarkar MAR and Zaman F (2012). Effect of spacing and number of seedlings per hill on the performance of aus rice cv. NERICA 1 under dry direct seeded rice (DDSR) system of cultivation. *Journal of the* Bangladesh Agricultural University, 10(2), pp.191-196.

Childs N (2020). RCS-20E, U.S Department of Agriculture, Economic Research Service, May 14, 2020. p.7

FAO and UNDP (1988). Land Resources Appraisal of Bangladesh for Agricultural Development Report No. 2. Agro-ecological Regions of Bangladesh. United Nations Development Program and Food and Agricultural Organization, Rome, Italy. pp. 212-221.

Gomez KA and Gomez AA (1984). Ducan's Multiple Range Test. Statistical Procedures for Agricultural Research. 2nd Edn., A Wiley Inter-Science Publication, Jhon Wiley and Sons, New York. p. 202–215.

Haque M, Razzaque A, Haque A, Ullah M (2011). Effect of plant spacing and nitrogen on yield of transplant aman rice var. BRRI dhan52. Journal of Bioscience and Agriculture Research, 4(02):52-59.

Laila N, Sarkar MAR, Paul SK Rahman A (2020). Yield performance of aromatic fine rice as influenced by integrated use of vermicompost and inorganic fertilizers. Journal of Bangladesh Agricultural University, 18(2):260–265. https://doi.org/10.5455/JBAU.90309.

Mahato P, Gunri SK, Chanda K, Ghosh M (2007). Effect of varying levels of fertilizer and spacing on medium duration rice (*Oryza sativa* L.) in terai zone of West Bengal. Karnataka Journal of Agricultural Science 20(2):363-365.

Miah MHN, Karim MA, Rahman MS and Islam MS (1990). Performance of Nitrogen nutrients under different row spacing. Bangladesh J. Train. Dev. 3(2):31–34.

Mobasser H, Tari D, Vojdani D, Abadi R and Eftekhari A, (2007). Effect of seeding age and planting space on yield and yield components of rice (Neda variety). Asian J. of Plant Sci., 6(20): 438-440.

Mohaddesi A, Abbasian A, Bakhshipour S and Aminpanah H (2011). Effect of different levels of nitrogen and plant spacing on yield, yield components and physiological indices in high-yield rice (number 843).American-Eurasian J. Agric. Enviro. Sci. 10: 893–900.

Pandey M (2021). Performance of rice cultivar CR Dhan 307 (Maudamani) as influenced by different planting densities in terai zone of West Bengal, ~ 489 ~ The Pharma Innovation Journal, 10(8), pp. 489–495.

Rasool F, Habib R, Bhat MI (2013). Agronomic evaluation of rice (Oryza sativa L.) for plant spacings and seedlings per hill under temperate conditions. African Journal of Agricultural Research 8(37):4650-4653.

Rautaray SK, 2007. Effect of spacing and fertilizer dose on grain yield of rice (Oryza sativa L.) in rice-rice cropping sequence. *Oryza*, 44(3), p.285.

Roy S, Islam N, Hoshain S, Hasan AK, Hossen K (2017) Effect of bed width and hill spacing on the performance of T. Aman rice cv. Superamandhan. International Journal of Sustainable Crop Production, 12(3): 1-6.

Salma M (2017) Effect of variety and planting density on weed dynamics and yield performance of transplant Aman rice, *banglajol.info*, 2(15), pp. 167–173. doi:10.3329/jbau.v15i2.35058.

Sayeed KA, Yunus MM (2018). Rice prices and growth, and poverty reduction in Bangladesh, FAO, Rome, Italy.

Uddin MJ, Hasan MM, Ahmed S, Hasan MM (2010). Effect of spacing on morpho-physiological response of different T. Aman rice cultivars under coastal high land ecosystem. Indian Journal of Agriculture Research, 44(4):251- 258.

Verma AK, Pandey N and Tripathi J (2002). Effect of transplanting spacing and number of seedling on productive tiller, spikelet sterility, grain yield and harvest index of hybrid rice. Intl. Rice Res. Notes. 27(1): 51.