Bangladesh Agron. J. 2019, 22 (1): 27-37

PERFORMANCE OF HYBRID RICE (Bio-453) IN VARIATION OF SPACING AND NUMBER OF SEEDLING PER HILL

D. Chowdhury[1], M. Biswas[2], M.N.H. Miah[1], P. Mandal[1] and M.S. Hossain[1*]

[1]Department of Agronomy and Haor Agriculture, Sylhet Agricultural University, Sylhet, Bangladesh
[2]Department of Agro Product Processing Technology, Jessore University of Science and Technology, Jessore, Bangladesh
*Corresponding E-mail: sazzadmh.aha@sau.ac.bd

(**Received:** 25 March 2019, **Accepted:** 30 May 2019)

Keywords: Hybrid rice, seedling hill^{-1}, spacing, growth and yield

Abstract

Hybrid rice production can ensure to get more yields per unit land. The research work was carried out to evaluate the effect of number of seedling hill^{-1} and spacing on the growth and yield of hybrid rice line Bio-453. The experiment was laid out in a split-plot design with 3 replications at the field of Agronomy and Haor Agriculture Department of Sylhet Agricultural University, under the AEZ 20 in Kharif-II (Aman) season of 2013. Number of seedling hill^{-1} was assigned in the main plot and plant spacing in the sub-plot. Two levels of seedling hill^{-1} viz. NS_1 (1 seedling hill^{-1}) and NS_2 (2 seedlings hill^{-1}) and five levels of plant spacing viz. Sp1 (15 cm x 15 cm), Sp2 (15 cm x 20 cm) and Sp3 (20 cm x 20 cm), Sp4 (20 cm x 25 cm) and Sp5 (20 cm x 30 cm) were the treatments. Number of seedling hill^{-1} and plant spacing showed significant effect in yield and yield contributing parameters except days to maturity, plant height, 1000-grain weight, total tillers hill^{-1}, number of effective tillers hill^{-1}, harvest index and grains panicle^{-1}. Maximum grain yield (9.43 t ha^{-1}), straw yield (16.27 t ha^{-1}) and biological yield (25.70 t ha^{-1}) were obtained from 1 seedling hill^{-1} (NS1) with the closest spacing 15 cm x 15 cm Therefore, one seedling hill^{-1} with 15 cm distance for plant and row to row distance could ensure maximum yield of hybrid rice line Bio-453.

Introduction

In Bangladesh soil and climatic conditions are favorable for rice cultivation and it is extensively cultivated throughout the year in three seasons namely Aus, Aman and Boro which covers 80% of the total cultivable area of the country (AIS, 2011). In respect of production, it ranks 4th place among the rice producing countries of the world (FAO, 2018). However, the average rice yield in Bangladesh is lower than the other rice growing countries like China, Japan, Korea (FAO, 2009). Besides the cultivable land is converting into non cultivable land around @1% every year (Quasem, 2011). In this situation hybrid rice production can be a good option to contribute to increase rice yield about 15-20% over the modern varieties (Julfiquar *et al.*, 2001). Bangladesh Rice Research Institute (BRRI) already released six hybrid rice varieties in Boro and T. aman, however only two rice hybrids released for T. aman season. But recently farmers are reluctant to cultivate more hybrid rice because of its higher requirements of fertilizer, irrigation etc. than the conventional rice either local or HYV which ultimately increase the cost of production. Sylhet is situated in the North-East portion of Bangladesh which is comparatively a higher rainfall area. T. aman occupying a major percentage in the cropping patterns of this area (DAE, 2012).

Number of seedling hill^{-1} plays an important role to enable the plant to grow properly both in its aerial and underground parts by utilizing maximum radiant energy, nutrient, space and water and also could reduce seedlings cost of farmers. Proper plant spacing responsible for the plant density that can minimize the seed requirement without sacrificing productivity of hybrid rice cultivation. Profuse tillering of the hybrid rice may compensate the yield due to reduction in plant population (Srinivasulu *et al.*, 1999). The growth, development, yield and yield components of rice are greatly influenced by plant spacing through proper utilization of solar radiation, soil and applied nutrients (Akter, 2004). When the plant densities and seedling hill^{-1} exceed optimum level, competition among them for light and nutrients become severe. Consequently, the growth rate slows down and the grain yield decreases. Wider spacing can produce more tillers when soil, water and nutrients are sufficiently available that produce higher yield. Keeping in view, a new advanced Hybrid rice line Bio-453 under two levels of seedling hill^{-1} and five levels of plant spacing were undertaken to know the effect of number of seedling hill^{-1} and spacing on yield and yield attributes.

Materials and Methods

The study was carried out at the field of Agronomy and Haor Agriculture Department of Sylhet Agricultural University, in Kharif-II (Aman) season during July to November 2013.The experiment was laid out in a split-plot design with three replications where main plot includes number of seedling hill^{-1} such as: 1) seedling hill^{-1} (NS_1) and 2) seedlings hill^{-1} (NS_2) and in sub-plot assigned plant spacing such as:i) 15 cm Ч 15 cm (Sp1), ii) 15 cm x 20 cm (Sp2), iii) 20 cm x 20 cm (Sp3), iv) 20 cm x 25 cm (Sp4) and v) 20 cm x 30 cm (Sp5).The size of the unit plot was 4.8 m^2 Hybrid rice line Bio-453 was collected from Bioseed Research India Pvt. Ltd. Sprouted seeds were sown in the well-prepared wet nursery bed. Thirty-four days old seedling was transplanted at a depth of 3-5 cm. During transplanting 5-7 cm water depth was maintained in each plot. Different intercultural operations were done for ensuring the normal growth of the crop. The experimental field was ploughed leveled well and well decompose cow dung was applied @5 t ha^{-1}. Dolochun lime was applied @0.75 t ha^{-1} to increase soil pH. The experimental area was fertilized with 68.72 kg, 10.98 kg, 41.81 kg, 14.04 kg, 1.1 kg of N, P, K, S and Zn per hectare, respectively (BRRI, 2013). One-third of urea and the entire TSP, MoP, gypsum and zinc oxide were incorporated into the soil during final land preparation. Remaining two-thirds of urea was top dressed at 40 days after transplanting (DAT) and at 55 DAT. Data were collected on yield and yield attributes. The collected data were tabulated and analyzed using computer package program R. Mean differences were adjudged by the Least Significant Difference (LSD) test at 5% level of significance.

Results and Discussion

Plant height

Effect of number of seedling hill^{-1} (NS)

No significant differences were observed on plant height at different DAT in variation of number ofseedlingshill^{-1}.

Effect of spacing (Sp)

Plant spacing exerted significant effect on plant height at different DAT (Fig. 1). Although the maximum plant height (135.50 cm) was recorded atSp2 which was similar to Sp1 (135.12 cm) and spacing Sp4 (130.58 cm). The minimum plant height (122.74 cm) was obtained from the widest spacing Sp5.

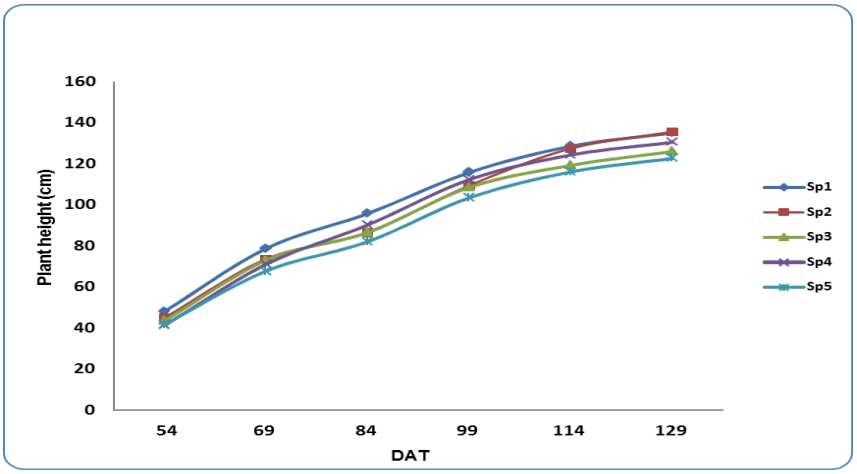

Fig. 1. Effect of spacing (Sp) on plant height at different days after transplanting (DAT) (LSD = 3.67, 4.08, 5.24, 4.37, 6.18 and 7.02 at 54, 69, 84, 99, 114 and 129 DAT, respectively.

Interaction effect of number of seedling hill^{-1} and spacing

Plant height at different DAT was significantly influenced by the interaction between number of seedling hill^{-1} and spacing (Fig. 2). The maximum plant (143.68 cm) was recorded from $NS_1ЧSp_1$ that was statistically closer to the plant height of $NS_1ЧSp_2$ and $NS_2ЧSp_4$ (140.90 cm and 140.18 cm). The shortest plant height was observed in treatment of $NS_1ЧSp_5$ that was statistically similar to $NS_1ЧSp_4$ and $NS_2ЧSp_3$.The result was similar with the findings of Ninad *et al.* (2017), Shrirame *et al.* (2000) and Shah *et al.* (1991).

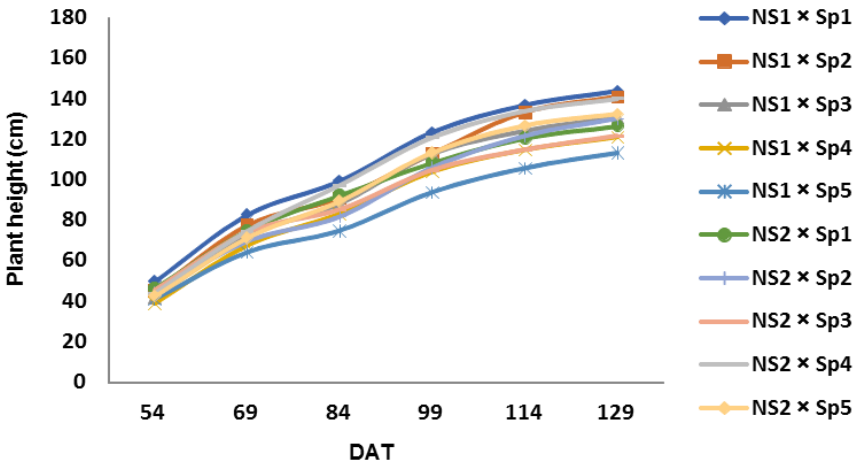

Fig. 2. Interaction effect of number of seedling hill^{-1} and spacing on plant height at different DAT (LSD = 5.19, 5.77, 7.41, 6.19, 8.74 and 9.92 at 54, 69, 84, 99, 114 and 129 DAT, respectively).

Number of tiller hill^{-1} at every 15-day intervals
Effect of number of seedlings hill^{-1}

Number of seedling hill^{-1} had significant effect on number of tiller hill^{-1}at earlier stage but no significant effect on later stage (Fig. 3). The higher number of tiller hill^{-1} (8.22) was obtained from NS_2at 84 DAT and the lower number of tiller hill^{-1} (5.81) was obtained from NS_1 at 54 DAT.

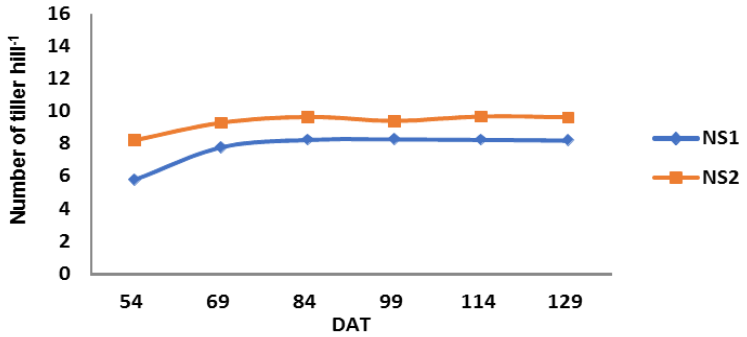

Fig. 3. Effect of number of seedling hill^{-1} (NS) on number of tiller hill^{-1} at different DAT (LSD = 0.66, 0.13, 0.98, 1.90, 2.13 and 1.97 at 54, 69, 84, 99, 114 and 129 DAT, respectively).

Effect of spacing

There was significant effect of plant spacing on number of tiller hill^{-1} at different DAT except 54 DAT (Fig. 4). The maximum number of tiller hill^{-1}(11.87) was obtained from the spacing of Sp_5 at 99 DAT. The minimum number (7.43) was found from the spacing of Sp_1at 54 DAT which was statistically similar to the number of tiller hill^{-1} 7.46 and 8.23 with the spacing of Sp_2 and Sp_3, respectively.

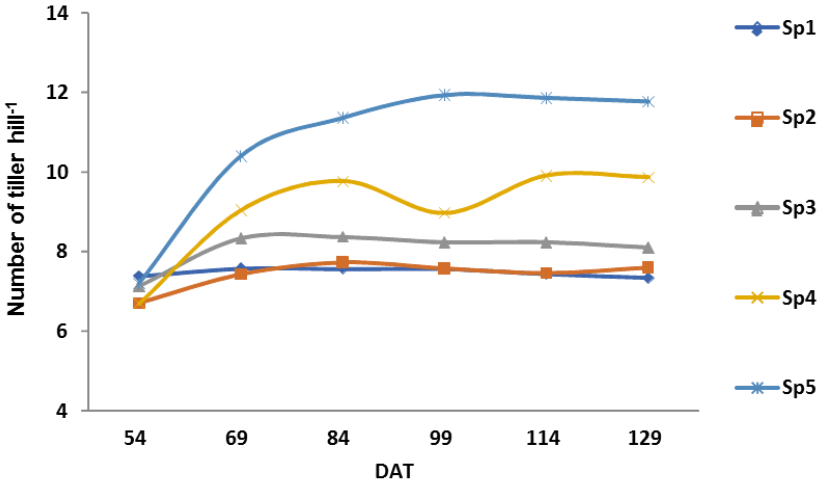

Fig. 4. Effect of spacing on number of tiller hill^{-1} at different DAT (LSD = 0.84, 1.37, 1.17, 1.20, 1.60 and 1.35 at 54, 69, 84, 99, 114 and 129 DAT, respectively).

Interaction effect of number of seedling hill^{-1} and spacing

Number of tiller hill^{-1} at 114 DAT was significantly influenced by interaction between number of seedling hill^{-1} and spacing (Fig. 5). The highest number of tiller hill^{-1} (13.27) was found from $NS_2ЧSp_5$ at 99 DAT. The lowest number (5.13) was obtained from $NS_1ЧSp_1$ at 54 DAT.

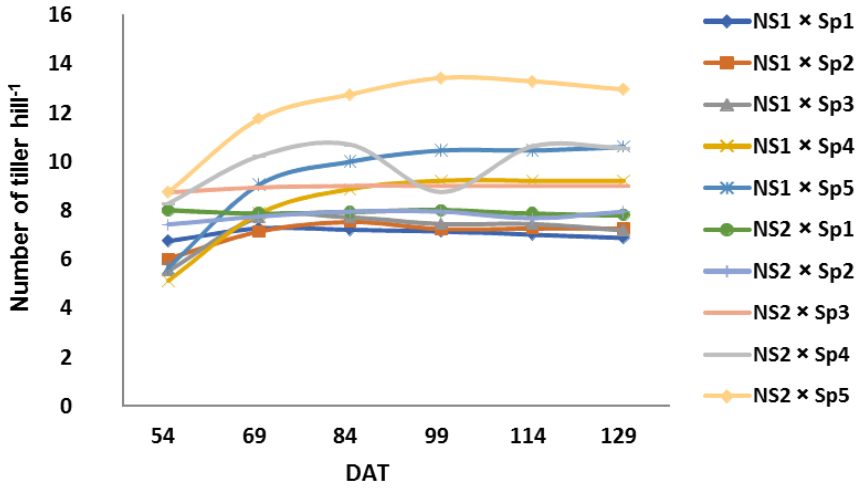

Fig.5 Interaction effect of number of seedling hill^{-1} and spacing on number of tiller hill^{-1}at different DAT (LSD = 1.19, 1.93, 1.66, 1.70, 2.26 and 1.91 at 54, 69, 84, 99, 114 and 129 DAT, respectively).

Phenology, yield components and yield
Effect of number of seedling hill^{-1}
Number of seedling hill^{-1} had no significant effect on days to 50% panicle initiation, days to maturity, plant height at harvest (Table 1). Shrirame *et al.* (2000) observed similar results. Gupta (1996) also found that transplanting of one seedling hill^{-1} significantly increased plant height. This observation was also supported by Nayak *et al.* (2003) who stated that plant height recorded significantly more with 1 seedling hill^{-1} than the 2 seedlings hill^{-1}. Similar result was found in case of non-effective tiller hill^{-1}, panicle length, grains panicle^{-1}, Weight of 1000-grain, grain yield, straw yield, biological yield. Rajarathinam (1999) similarly stated that the straw yield of hybrid rice was not changed significantly due to planting of single or double seedlings hill^{-1}. Number of total tiller hill^{-1} and effective tiller hill^{-1} were significantly influenced by number of seedling hill^{-1} (Table 1). The higher number of total tiller hill^{-1} (12.13) was found in 2 seedlings hill^{-1} (NS2) and the lower one (10.91) with 1 seedling hill^{-1} (NS1). Alam (2006) reported similarly that highest number of effective tillers was obtained from 2 seedlings hill^{-1}. Number of seedling hill^{-1} had no significant effect on harvest index (Table 1).

Table 1. Phenology and yield components of hybrid rice line Bio-453 as influenced by number of seedlings hill^{-1}

No. of Seedling hill^{-1} (NS)	Days to 50% flowering	Days to maturity	Plant height (cm)	Total tiller hill^{-1} (no.)	Effective tiller hill^{-1} (no.)	Non-effective tiller hill^{-1} (no.)	Panicle length (cm)
NS_1	105	137	131.69	10.91 b	8.55 b	2.36	24.53
NS_2	105	130	131.41	12.13 a	9.35 a	2.77	24.35
LSD $_{(0.05)}$	NS	NS	NS	1.17	0.84	NS	NS

Cont'd

No. of seedling hill^{-1}	Grain panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
NS_1	81.24	27.15	8.38	13.17	21. 72	38.69
NS_2	80.15	26.77	8.02	13.06	21.08	38.08
LSD $_{(0.05)}$	NS	NS	NS	NS	NS	NS

Note: NS_1 = 1 seedling hill^{-1}; NS_2 = 2 seedlings hill^{-1}; NS = Non-significant; * indicate 5% level of significance.

Effect of spacing

Days to maturity, plant height, panicle length, grain panicle^{-1}, 1000 grain weight and harvest index was not significantly affected by plant spacing (Table 2).

Days to 50% flowering

Plant spacing had significant effect on days to 50% flowering (Table 2). Maximum days (107) required for 50% flowering at the spacing of Sp_4 and Sp_5 whereas statistically minimum days (103) required at the spacing of Sp_1, Sp_2 and Sp_3.

Total tiller hill^{-1}

Plant spacing had significant effect on number of total tiller hill^{-1} (Table 2). The maximum number of total tiller hill^{-1} (13.61) was found in the wider Sp_5 which was statistically similar to spacing Sp_4. The lowest number (9.50) was observed in the closest spacing Sp_1. The plants grown in Sp_5 possibly experienced more light, space, air and nutrient facilities which stimulated positively towards tiller formation than the closer spacing.

Effective tillers hill^{-1}

The number of effective tillers hill^{-1} was significantly influenced by spacing (Table 2). The maximum number of effective tillers hill^{-1} (10.88) was obtained from Sp_5 which was statistically similar to theSp_4 (10.61). The lowest one (7.43) was obtained from Sp_2 which was statistically similar with Sp_2 and Sp_3 (7.61 and 8.10, respectively). The result showed that Sp_5 had the greatest opportunity to produce more number of effective tillers hill^{-1} because it gets enough space, nutrients, light and air which played great role in producing more effective tillers hill^{-1}. Baloch *et al.* (2002) reported wider spaced plant produced more effective tillers in rice than closer one.

Non-effective tillers hill^{-1}

The number of non-effective tillers hill^{-1} was significantly influenced by spacing (Table 2). The highest number of non-effective tillers hill^{-1} (2.94) was found in Sp_3 which

was statistically closer to the number of non-effective tillers hill^{-1}of 2.72 and 2.82 with the spacing Sp_2 and Sp_5, respectively. The lowest number (2.04) was found in the spacing Sp_1 which was statistically similar to the Sp_4 (2.39).

Grain yield
Plant spacing had significant effect on grain yield (Table 2). The maximum grain yield (8.93 t ha^{-1}) was obtained from Sp_1 which was statistically similar with Sp_2 and Sp_3 (8.63 and 8.45 t ha^{-1}). The result was similar to Ninad *et al.* (2017) and Chandra *et al.* (1997) who recorded that the closer spacing 15 cm x 15 cm gave 10-12% higher yield than the other spacing. The lowest yield (7.28 tha^{-1}) was obtained from the spacing 20 cm x 30 cm (Sp_5) which was also statistically similar to the grain yield of 7.66 t ha^{-1} obtained from the spacing 20 cm x 25 cm (Sp_4). The results revealed that closest spacing gives higher yield performance whereas wider spacing gave lower yield. This might be due to the fact that closest spacing had higher plant population (i.e. hill unit^{-1} area) than the corresponding wider spacing in spite of higher number of effective tillers hill^{-1}, filled grains panicle^{-1} and 1000-grain weight. The result corroborates with the findings of other few research findings that closer spacing had higher grain yield than the other spacing (Azad *et al.*, 1995; Patel, 1999; Obulamma *et al.*, 2002).

Straw yield
Straw yield was significantly influenced by spacing (Table 2). The maximum straw yield (14.47 t ha^{-1}) was produced from the closest spacing 15 cm x 15 cm (Sp_1) which was statistically closer to the straw yield (14.17 t ha^{-1}) obtained from the spacing 15 cm x 20 cm (Sp_2). The moderate straw yield (13.02 t ha^{-1}) was recorded from the spacing 20 cm x 20 cm (Sp_3) which was statistically similar to the straw yield (12.57 t ha^{-1}) obtained from the spacing 20 cm x 25 cm (Sp_4). The minimum yield (11.35 t ha^{-1}) was produced from the widest spacing of 20 cm x 30 cm (Sp_5). The results showed that straw yield increased with closer spacing and decreased with wider spacing.

Biological yield
Plant spacing exerted significant effect on biological yield (Table 2). The highest biological yield (23.40 t ha^{-1}) was obtained from the closest spacing Sp_1 which was statistically similar to the biological yield Sp_2 (22.85 t ha^{-1}). The lowest biological yield (18.63 t ha^{-1}) was obtained from the widest spacing Sp_5. The result showed that closer spacing provided the highest biological yield. It might be due to the fact that closer spacing had more population densities which added more biomass that was accumulated before flowering and translocated to the grains during grain filling.

Table 2. Phenology and yield components of hybrid rice line Bio-453 by spacing

Plant Spacing (Sp)	Days to 50% flowering	Days to maturity	Plant height (cm)	Total tiller hill^{-1} (no.)	Effective tiller hill^{-1} (no.)	Non-effective tiller hill^{-1} (no.)	Panicle length (cm)
Sp_1	103 b	137	133.78	9.50 d	7.44 c	2.04 c	24.76
Sp_2	104b	137	134.77	10.45 c	7.61 c	2.82 ab	24.53
Sp_3	104 b	137	130.05	11.05 c	8.22 c	2.94 a	24.21
Sp_4	107 a	137	131.55	12.50 b	9.72 b	2.39 bc	24.47
Sp_5	107 a	137.67	127.61	14.11 a	11.78 a	2.72 ab	24.22

(Continued)

Plant Spacing	Grain panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Sp_1	81.55	26.93	8.93 a	14.47 a	23.40 a	38.33
Sp_2	79.61	26.03	8.68 a	14.17 ab	22.85 a	37.93
Sp_3	79.16	26.93	8.45 a	12.57 c	21.01 b	40.20
Sp_4	83.66	27.68	7.67 b	13.39 bc	21.06 b	36.35
Sp_5	79.50	27.21	7.28 b	11.35 d	18.63 c	39.13

Note: Sp_1 = 15 cm x 15 cm; Sp_2 = 15 cm x 20 cm; Sp_3 = 20 cm x 20 cm, Sp_4 = 20 cm x 25 cm; Sp_5 = 20 cm x 30 cm

Interaction effect of number of seedling hill^{-1} and spacing

Days to 50% flowering

Days to 50% flowering, days to maturity, plant height, total tillers hill^{-1}, panicle length, grains panicle^{-1}, 1000-grain weight and harvest index was not significantly influenced by the interaction between number of seedling hill^{-1} and spacing (Table 3).

Effective tillers hill^{-1}

Number of effective tillers hill^{-1} was significantly affected by interaction between number of seedling hill^{-1} and spacing (Table 3). The highest number of effective tillers hill^{-1} (12.22) from 2 seedlings hill^{-1} (NS_2) with 20 cm x 30 cm spacing (Sp_5) which was statistically similar to1 seedling hill^{-1} (NS_1) with 20 cm x 30 cm spacing (Sp_5). The number of effective tillers hill^{-1} of 7.63 and 7.88 recorded from 2 seedlings hill^{-1} (NS_2) with the spacing 15 cm x 15 cm (Sp_1) and 15 cm x 20 cm (Sp_2), respectively was statistically similar. The lowest number (7.22) was recorded from 1 seedling hill^{-1} (NS_1) with the spacing of 15 cm x 15 cm (Sp_1) that was statistically similar to 1 seedling hill^{-1} (NS_1) with 15 cmЧ x 20 cm (Sp_2) and
20 cm x 20 cm (Sp_3) spacing, respectively.

Non-effective tillers hill^{-1}

There was significant effect by the interaction between number of seedling hill^{-1} and spacing on number of non-effective tillers hill^{-1} (Table 3). The maximum number of non-effective tillers hill^{-1} (3.55) was found in $NS_2Ч Sp_2$which was significantly closer to NS_1Sp_3 and NS_1Sp_4, respectively. The minimum number (1.66) was obtained from NS_1Sp_1 which was as at par to (NS_1Sp_2) and (NS_1Sp_5), respectively.

Grain yield

Significant influence by interaction between number of seedling hill^{-1} and spacing on grain yield was found (Table 3). Maximum grain yield (9.43 t ha^{-1}) was obtained from $NS_1ЧSp_1$ which was statistically similar to NS_1Sp_2 and NS_1Sp_3 (9.26 and 8.86 t ha^{-1} respectively). The result corroborates with the findings of (Strivastava and Tripathi, 1998) that 1 seedling hill^{-1} in combination with the spacing 15 cm x 15 cm (Sp_1) produced the highest grain yield in hybrid rice. Minimum grain yield (7.0 t ha^{-1}) was obtained from (NS_1Sp_5) which was significantly similar to the grain yield (7.36 t ha^{-1}) from NS_1Sp_4. The results revealed that the combination of single seedling hill^{-1} with closer spacing had higher yield performance whereas the combination of single seedling hill^{-1} with wider spacing had lower yield performance.

Straw yield

The interaction between number of seedling hill^{-1} and spacing exerted significant effect on straw yield (Table 3). The maximum straw yield (16.27 t ha^{-1}) was produced from $NS_1Ч Sp_1$ that was statistically similar to the straw yield (14.83 t ha^{-1}) at NS_1Sp_2. The lowest straw yield (10.43 t ha^{-1}) was produced from $NS_1ЧSp_5$ which was similar to $NS_1Ч Sp_3$ (11.77 t ha^{-1}). The straw yield (12.53 t ha^{-1}) produced at 1 seedling hill^{-1} (NS_1) with the spacing of 20 cm x 25 cm (Sp_4) statistically similar to the straw yield of 12.67 t ha^{-1}, 12.60 t ha^{-1} and 12.27 t ha^{-1} recorded from 2 seedlings hill^{-1} (NS_2) with the spacing of 15 cm x 15 cm (Sp_1), 20 cm x 25 cm (Sp_4) and 20 cm x 30 cm (Sp_5), respectively.

Biological yield

Biological yield was significantly influenced by seedling hill^{-1} and spacing (Table 3). Maximum biological yield (25.70 t ha^{-1}) was found in ($NS_1ЧSp_1$) which was statistically similar with $NS_1ЧSp_2$ (24.10 t ha^{-1}). Minimum biological yield (17.43 t ha^{-1}) recorded from 1 seedling hill^{-1} (NS_1) with 20 cm x 30 cm spacing (Sp_5), which was significantly different from the others.

Table 3. Phenology and yield components of hybrid rice line Bio-453 by interaction effect of number of seedling hill^{-1} (NS) and spacing (Sp)

Interaction of NSSp	Days to 50% flowering	Days to maturity	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Panicle length (cm)
NS_1 x Sp_1	103	137	141.00	8.89	7.22	1.66 d	25.04
NS_1 x Sp_2	106	138	140.88	9.44	7.36	2.05 cd	24.77
NS_1 x Sp_3	105	137	132.78	10.33	7.23	3.12 ab	24.05
NS_1 x Sp_4	106	134	123.11	12.44	9.55	2.88 ab	24.75
NS_1 x Sp_5	106	137	120.67	13.44	11.33	2.10 cd	24.02
NS_2 x Sp_1	104	136	126.56	10.11	7.63	2.44 bcd	24.48
NS_2 x Sp_2	103	136	128.65	11.44	7.88	3.55 a	24.27
NS_2 x Sp_3	102	137	127.33	11.78	9.11	2.66 bc	24.36
NS_2 x Sp_4	107	138	139.98	12.56	9.89	2.67 bc	24.18
NS_2 x Sp_5	108.0	138	134.56	14.78	12.22	2.56 bc	24.43

(Continued)

Interaction of NSSp	Grain panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
NS_1 x Sp_1	84.22	27.43	9.43 a	16.27 a	25.70 a	36.66
NS_1 x Sp_2	83.78	26.89	9.26 ab	14.83 ab	24.10 ab	38.33
NS_1 x Sp_3	76.77	26.60	8.86 abc	12.53 de	21.40 cd	41.43
NS_1 x Sp_4	80.11	26.83	7.36 ef	11.77 ef	19.96 d	36.90
NS_1 x Sp_5	77.28	26.90	7.00 f	10.43 f	17.43 e	40.13
NS_2 x Sp_1	83.10	27.93	8.43 bcd	12.67 cde	21.10 cd	40.00
NS_2 x Sp_2	75.44	26.36	8.10 cde	13.50 bcd	21.60 cd	37.53
NS_2 x Sp_3	81.55	27.27	8.03 cde	12.60 de	20.63 cd	38.96
NS_2 x Sp_4	82.99	27.03	7.96 cdef	14.27 bc	22.23 bc	35.80
NS_2 x Sp_5	80.72	27.20	7.56 def	12.27 de	19.83 d	38.13

Note: NS= Number of seedling; Sp= Spacing.

Conclusion

From the experimental findings it is clear that hybrid rice line Bio-453 planted with 1 seedling hill^{-1} along with 15 cm x 15 cm spacing produced maximum grain yield (9.43 t ha^{-1}) while combination of 2 seedlings hill^{-1} along with 20 cm x 30 cm spacing contributed lower yield (7.56 t ha^{-1}). Consequently, hybrid rice line Bio-453 with the combination of 1 seedling hill^{-1} with 15 cm x 15 cm spacing to be the best possible combination for achieving higher grain yield per unit area.

References

AIS. 2011. Krishi Dairy, Agril. Inform. Ser. Kamarbari, Farmgate, Dhaka, Bangladesh.

Akter, F.M.F. 2004. Effect of plant spacing and nitrogen level on the performance of transplant aman rice. MS Thesis, Dept. of Agron., Bangladesh Agril. Univ., Mymensingh, Bangladesh.

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

Azad, A.K., M.A. Gaffer, S.C. Samanta, M.A. Kashem and M.T. Islam. 1995. Response of Brio Rice to Different Levels of Nitrogen and Spacings. Bangladesh J. Sci. Indus. Res. 30: 31–38.

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.

BRRI. 2013. Adhunik dhaner chash, 17th edition. Gazipur.

Chandra, D., S.B. Lodh, K.M. Sahoo and B.B. Nanda. 1997. Effect of date of planting and spacing on grain yield and quality of scented rice (*Oryza sativa*) varieties in wet season in coastal Orissa. Indian J. Agric. Sci. 67: 93–97.

DAE. 2012. Report on cropping pattern of Sylhet. Sylhet, Bangladesh.

FAO. 2009. Production Yearbook. Food and Agric. Organiz. United Nations, Rome, Italy.

FAO. 2018. FAOSTAT database of Agriculture (Crops). Food and Agric. Organiz.

United Nations, Rome, Italy.

Gupta, S.K. 1996. Effect of planting seedling and nitrogen on yield of rice (*Oryza sativa*). Indian J. Agron. 41: 581–583.

Julfiquar, A.W., S.S. Virmani, M.M. Haque, M.A. Mazid and M.M. Kamal. 2001. Hybrid rice in Bangladesh: opportunities and challenges. International Rice Research Conference, Los Bacos, Laguna (Philippines), 31 Mar-3 Apr 2000 IRRI, Philippines.

Nayak, B.C., B.B. Dalei and B.K. Choudhury. 2003. Response of hybrid rice (*Oryza sativa*) to date of planting, spacing and seedling rate during wet season. Indian J. Agron. 48: 172–174.

Ninad, T.A., M.M. Bahadur, M.A. Hasan, M.M. Alam and M.S. Rana. 2017. Effect of Spacing and Seedling Per Hill on the Performance of Aus Rice var. BRRI dhan48. Bangladesh Agron. J. 20: 17-26.

Obulamma, U., R. Reddeppa and R. Reddy. 2002. Effect of spacing and seedling number on growth and yield of hybrid rice. J. Res. Angrau. 30: 76–78.

Patel, J.R. 1999. Response of rice (*Oryza sativa*) to time of transplanting, spacing and age of seedings. Indian J. Agron. (India). 44: 344-346.

Quasem, M.A. 2011. Conversion of agricultural land to non-agricultural uses in Bangladesh: Extent and determinants. The Bangladesh Development Studies.pp.59–85.

Rajarathinam, P. 1999. Optimum plant population, seedling density and N levels for medium duration hybrid rice (*Oryza sativa*). Indian J. Agric. Sci. 69: 583–585.

Shah, M.H., M.K. Khushu, B.A. Khanday and A.S. Bali. 1991. Effect of spacing and seedlings per hill on transplanted rice under late sown condition. Indian J. Agron. 36: 274-275.

Shrirame, M.D., H.J. Rajgire and A.H. Rajgire. 2000. Effect of spacing and seedling number per hill on growth attributes and yield of rice hybrids under lowland condition. J. Soil. Crop. 10: 109–113.

Srinivasulu, K., R. Veeraraghavaiah and K. Madhavi. 1999. Growth performance of rice hybrids under different methods and densities of planting. Crop Res. 18: 1–7.

Strivastava, O.K. and R.S. Tripathi. 1998. Response of hybrid and composite rice to number of seedling and planting geometry. Ann. Agric. Res. Newsl. pp.235-236.