Original Research Article

Effect of plant spacing on the growth and yield of local *aman* rice cultivars

ABSTRACT

Aims: In Sylhet region of Bangladesh, there is a great genetic diversity of local rice cultivars which can be able to cope-up with climate changes. Transplant (T) *aman* is occupying a major portion of rice based cropping system. Agronomic management can be a good option to boost up the yield potential of these local cultivars. This study were conducted to observe the influence of planting geometry on the yield of local *aman* cultivars.
Study design: Randomized complete block design.
Place and Duration of Study: The experiment was conducted to find out optimum plant density of local cultivars of T. aman rice during the period from August 2017 to December 2017 at farmer's field located at Jointapur Sylhet
Methodology: The study were replicated thrice in randomized complete block design considering four rice cultivars viz. Beruin (V1), Moinasail (V2), Nagrasail (V3) and, BRRI dhan 49 (Control, check variety) (V4). The experiments comprised of all varieties; four plant spacing viz. (15 × 15) cm (S1), (20 × 15) cm (S2), (20 × 20) cm (S3) and (20×25) cm (S4).
Results: The results indicated that the highest grain yield were recorded in (2.65 t ha^{-1}) in the variety V4, which was statistically similar with V3 (2.60 t ha^{-1}). The highest grain yield (2.87 t ha^{-1}) was obtained (V4 × S4) while the lowest (1.58 t ha^{-1}) from (V1 × S1). Among the local varieties highest grain yield (2.64 t ha^{-1}) recorded in (V3 × S4) which was statistically similar (V4 × S4).
Conclusion: Outcomes of the study revealed that Nagrasail (V3) with (20 × 25) cm plant spacing is a promising option, and is the best one for local T. *aman* cultivar cultivation in Sylhet region.

Key words: Local aman rice, plant spacing, growth, yield

1. INTRODUCTION

Rice (*Oryza sativa*) is one of the most widely and leading cultivated cereal crop in the world in its annual contribution to food consumption (Latha *et al,* 2004 . It is the staple food for over half the world's population of an estimated 3.5 billion people worldwide and annual production of milled rice is approximately 480 million metric tons (Muthayya *et al,* 2014, IRRI 2013). Rice production and consumption are among the highest in Asian people. In 2014, Asian countries contributed 90% (667.258311million tons) whereas the total world production of rice was 740.955973 million tons (FAO 2015). World population is increasing day by day and more foods need to be produced to meet up the food demand. It is necessary to enhance rice production in Bangladesh through increasing land productivity to meet up the increasing demand for food and strengthen food security.

In Sylhet region of Bangladesh, there is a great genetic diversity of local rice cultivars which can be able to cope-up with climate changes. Still a good number of indigenous genotypes of fine, aromatic and glutinous rice remain under cultivation in Sylhet region competing with HYV's due to special qualities fetches high price locally and good demand in the ethnic market in UK and USA. In Sylhet district, local cultivars cover about 2478 ha (5.23%) of *aus* rice area, 50890 ha (36.3%) of *aman* rice area and 10990 ha (13.82%) of *boro* rice area (DAE 2016). Yield of these varieties is low because of unavailability of recommended agronomic management like planting geometry, fertilizer management, seedling age etc. which needs to be developed to boost-up yield and productivity.

Among different management practices, use of appropriate number of seedlings hill^{-1} and spacing are important. Plant density plays an important role on growth and yield of rice. Optimum plant spacing ensures the plant to grow properly with their aerial and underground parts by utilizing more solar radiation and soil nutrients (Miah *et al,* 1990). Closer spacing hampers intercultural operations. Also in a densely populated crop favours more straw yield than grain yield due to the inter-plant competition is very high for nutrients, air and light, which usually results in mutual shading, lodging. On the other hand, under wider plant spacing desired hill unit^{-1} area ultimately reduces yield unit^{-1} area. The maximum benefit can be derived from a rice field, if the crop is properly spaced between rows and within rows. Alam (2006) stated that optimum spacing gave a maximum number of total tillers m^{-2}, maximum number of fertile tillers m^{-2} which was dependent on temperature, moisture and other soil factors. Shrirame *et al,* (2000) reported that total number of tillers hill^{-1} was higher at the wider spacing. Hence, research is needed to develop appropriate plant spacing for the local T. *aman* rice cultivars traditionally grown in the Sylhet region. Therefore, the present study was conducted to identify suitable planting spacing to increase productivity of local T. *aman* rice for Sylhet region of Bangladesh.

2. MATERIALS AND METHODS

The experiment was conducted to find out optimum plant density of local cultivars of T. aman rice during the period from August 2017 to December 2017 at farmer's field located at Jointapur Sylhet which geographical position was 23^0 to 25^{0}1$^/$ North and 90^{0}57$^/$ to 92^{0}28$^/$ East longitude and latitude, respectively with the elevation of 34 meters above the mean sea level under the Eastern Surma-Kushiyara Floodplain; Agroecological Zone (AEZ-20). Experimental treatments included in the experiment were Factor A: Local aman rice cultivers: 4 (Four) i) Beruin (V1), ii) Moinasail (V2), iii) Nagrasail (V3), iv) BRRI dhan49 (HYV & Control) (V4) and Factor B**:** Hill spacing: 4 (Four) i). 15 cm x15 cm (S1), ii) 20 cm x 15 cm (S2), iii) 20 cm x 20 cm (S3), iv) 20 cm x 25 cm (S4).There were 16 treatment combinations in the experiment. Each combination was replicated thrice and thus there were altogether 48 plots in the experiment. The experiment was laid out in the Split plot Design assigning cultivar in the main plot and spacing in the sub-plot. The unit plot size was 3 m x 2 m. There was a bund of 0.50 m width between two experimental plots and each replication was separated by a bund of 0.5 m width. Fertilizers Urea, Triple Super Phosphate, Muriate of Potash, Gypsum and Zinc Sulphate were applied according to recommended dose (BRRI, 2011). The fertilizers were applied @ 90-15-60-12-1 kg ha^{-1} N, P, K, S and Zn for the variety of BRRI dhan49. For i. Beruin, ii. Moinasail and iii. Nagrasail, local rice varieties 45-9-33-9-1 kg ha^{-1} N, P, K, S and Zn, respectively were applied. Unit plot size was 6 m^2 (3 m x 2 m). For BRRI dhan49, in each plot, 20 g TSP, 60 g MoP, 40 g Gypsum and 1.7 g Zinc Sulphate were applied as basal. For BRRI dhan49 120 g Urea was applied into three equal splits-1/3rd at final land preparation, 1/3rd at 21 DAT (tillering stage) and 1/3rd at 36 DAT (active tillering stage) in each plot. For Beruin, Moinasailand Nagrasail 12 g TSP and 40 g MoP, 30 g Gypsum and 1.8 g Zinc sulphate were applied as basal. For local varieties 60 g Urea was also applied into three equal splits- 1/3rd at final land preparation, 1/3rd at 21 DAT (tillering stage) and 1/3rd at 36 DAT (active tillering stage) in each plot. Seeds of BRRI dhan49 were collected from Bangladesh Agricultural Development Corporation (BADC), Sylhet and seeds of other local varieties of Beruin, Moinasail, and Nagrasail were collected from local farmers. Seed rate used @ 10 kg ha^{-1} for each variety having germination percentages 93%, 95%, 92% and 95% for Beruin, Moinasail, Nagrasail and BRRI dhan49, respectively. About 52-day old were transplanted on the well puddle experimental plots on 23 September, 2017. Two-three seedlings hill^{-1} were transplanted maintaining the spacing as per treatments. Sufficient water depth (4-5 cm) was maintained in the plot during transplanting of seedling. Manual weeding was done at first at 21 DAT and 36 DAT in each plot. Gap filling was done while seedlings in some hills were died off within 10 days of transplanting. After transplanting 3-4 cm water depth was maintained throughout the life cycle of the crop but removed 10 days before maturity. For controlling insect-pest specially the stem borer (though this insect infestation was not considerable) granular insecticide Carbofuran 5G (Furadan) were applied @ 16 kg ha^{-1} by maintaining 4-5 cm water depth in the crop field at maximum tillering stage. Observations were made on plant height at harvest, number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, number of panicles hill^{-1}, length of panicle, number of filled grains panicle^{-1}, number of unfilled spikelets panicle^{-1}, 1000 grain weight, percentage of filled spikelet, grain weight plot^{-1}, straw weight plot^{-1} and harvest index.

Percentage of filled spikelet: Number of filled spikelet and unfilled spikelet panicle^{-1} constitutes total number of spikelets. From these data percentage of filled grains were calculated by using the following formula.

$$\text{Percentage of illed spikelet} = \frac{\text{No. of illed spikelets per panicle}}{\text{No. of total spikelets per panicle}} \times 100$$

Collected data were tabulated and analyzed by using computer software R. Mean separations were done at 5% level of significance by Least Significant Difference (LSD) Test wherever F values were significant at either 1% or 5% level of probability.

3. RESULTS

3.1. Plant height of rice varieties at irrespective of plant spacing’s

3.1.1. Plant height at 30 DAT

Plant height at 40 DAT significantly and the tallest plant (65.88 cm) was obtained from Moinasail (V2) and the shortest plant (41.30 cm) was obtained from BRRI dhan49 (V4) (Table 1). Other two varieties (V1 & V3) also differed significantly from each other.

3.1.2. Plant height at 60 DAT

Plant height varied significantly among the rice varieties. The result revealed that the variety Moinasail had the maximum height (102.17 cm) which was similar to that of Beruin (100.39 cm) and Nagrasail (V3) (93.28 cm). The shortest plant (65.95 cm) was recorded from BRRI dhan49 (Table 1). This observation was also supported by Hossain and Alam (1991) who also observed variations in plant height due to varietal differences.

3.1.3. Plant height at 75 DAT

Plant height differed significantly among the varieties at 75 DAT (Appendix 1). The tallest (109.85 cm) plant height was recorded in Nagrasail (V3) while the shortest plant (72.03 cm) was recorded from BRRI dhan49 (Table 1). Beruin (V1) variety produced moderate plant height (100.35 cm) which was similar to that of Moinasail (V2) (107.42 cm). Probably the genetic make-up of the varieties was responsible for the variation in plant height. The result was similar to Shamsuddin *et al. (*1988) who reported that plant height varied among the varieties.

3.1.4. Plant height at harvest

Finally at harvest, plant height was significantly varied due to the different varieties. The tallest (111.53 cm) plant was observed in Nagrasail (V3) and the shortest plant (78.07 cm) was recorded from BRRI dhan49 (Table 1). Moinasail also produced similar plant height (107.42 cm) to that of Nagrasail. Kabir *et al.* (2004) also observed variation in plant height due to varietal differences. Khisha (2002) observed that plant height was significantly influenced by varieties.

Table 1. Plant height of transplant *aman* rice varieties at irrespective of planting spacing's during T. aman season

Variety	Mean plant height (cm)			
	30 DAT	**60 DAT**	**75 DAT**	**Harvest**
V1	56.13c	100.39a	100.35b	102.85b
V2	65.88a	102.17a	104.42ab	107.42ab
V3	62.40b	93.28a	109.85a	111.53a
V4	41.30d	65.95b	72.03c	78.07c
CV(%)	**3.76**	**14.41**	**6.29**	**5.13**
LSD0.05	**2.12**	**13.02**	**6.08**	**5.13**

Note: V1= Beruin,V2= Moinasail,V3=Nagrasail,V4= BRRI dhan49

3.2. Plant height of rice varieties as influenced by spacing's

3.2.1. Plant height at 30 DAT

Plant height at 30 DAT significantly and the tallest plant (58.47 cm) was obtained from S1 which was similar to that of S3 (57.53 cm) (Table 2). The shortest plant (54.65 cm) was recorded from the spacing S3 which was similar to that of S2 (55.07 cm).

3.2.2. Plant height at 60 DAT

Plant height did not vary significantly the previous 45 DAT (Appendix 1). The result revealed that the plant height varies from 85.62 cm in 15 cm x 15 cm (S1) to 92.83 cm in 20 cm x 20 cm (S2) spacing (Table 2).

3.2.3. Plant height at 75 DAT

Plant height also did not differ significantly at 75 DAT due to variation in spacing. The results showed that plant height increment was slow from 45 DAT to 75 DAT. Minimum plant height (95.37 cm) was found in S1 while the maximum (97.45 cm) in S4 (Table 2).

3.2.4. Plant height at harvest

Plant height was significantly varied due to the different spacings. The tallest plant (100.58 cm) was observed in 15 cm x 15 cm (S1) spacing and the shortest plant (97.98 cm) was recorded from the 20 cm x 25 cm (S4) (Table 2). Plant height of S2 (100.27 cm) and S3 (101.03 cm) was similar to that of S1.

Table 2. Plant height of T. aman rice varieties as influenced by spacing's during T. aman season

Spacing	Mean plant height (cm)			
	30 DAT	**60 DAT**	**75 DAT**	**Harvest**
S1	58.47a	85.62	95.37	100.58a
S2	55.07b	92.53	96.40	100.27ab
S3	54.65b	92.83	97.43	101.03a
S4	57.53a	90.77	97.45	97.98b
CV(%)	**2.34**	**12.92**	**3.31**	**2.74**
LSD0.05	**1.11**	**9.84**	**2.69**	**2.31**

NB: S1=15 cm x 15 cm, S2=20 cm x 15 cm, S3=20 cm x 20 cm, S4= 20 cm x 25 cm.

3.3 Number of tiller hill^{-1} of rice as influenced by plant spacings

3.3.1. Number of tillers hill^{-1} at 30 DAT

Number of tillers hill^{-1} at 30 DAT differed significantly and the highest of number of tiller (11.58 hill^{-1}) was found in the variety Beruin (V1) (Table 3). Other two varieties V2 and V3 produced statistically similar number of tillers hill^{-1} to that of V1 while the lowest number of tiller (10.42 hill^{-1}) was found in the variety BRRI dhan49 (Table 3).

3.3.2. Number of tillers hill^{-1} at 45 DAT

At 45 DAT number of tillers hill^{-1} also varied significantly and the variety Beruin also produced the highest number of tiller (18.33 hill^{-1}) which was significantly different from others (Table 3). The lowest number of tiller (15.21 hill^{-1}) was found in the variety Nagrasail statistically similar to that of Moinasail and BRRI dhan49.

3.3.3. Number of tillers hill^{-1} at 60 DAT

There was significant variation among the varieties in terms of number of tillers hill^{-1} at 60 DAT. The results revealed that the local variety Beruin produced the highest number of tiller (20.42 hill^{-1}) followed by the variety BRRI dhan49 (18.17 hill^{-1}). The variety Nagrasail produced the lowest number of tiller (16.50 hill^{-1}) which was statistically similar to that of Moinasail (16.50 hill^{-1}) (Table 3).

3.3.4. Number of tillers hill^{-1} at 75 DAT

Number of tillers hill^{-1} at 75 DAT differed significantly. At 75 DAT unlike the results of the previous days of interval 30, 45 & 60, the variety BRRI dhan49 gave the highest number of tiller (19.71 hill^{-1}) which was similar to that of Beruin (V1) but significantly different from both the varieties Moinasail (V2) and Nagrasail (V3) (Tablee 3). The varieties V2 and V3gave similar number of tillers (16.29 and 15.92 hill^{-1}, respectively).

3.3.5. Number of tillers hill^{-1} at harvest

Number of tillers hill^{-1} at harvest differed significantly among the varieties. All varieties differed significantly from each other in terms of tillers hill^{-1} at harvest. It was observed that tillers hill-1 increased sharply from 30 DAT to 45 DAT. After 45 DAT. Tiller number hill^{-1} increased slowly up to 75 DAT and then some mortality was found which resulted reduced number of tillers hill^{-1} at harvest (Table 3). The lowest number of tiller (12.95 hill^{-1}) was found in the variety Moinasail (Table 3).

Table 3. Number of tiller hill^{-1} of T. aman rice varieties at irrespective of spacings during T. aman season

Variety	Mean number of tiller hill^{-1}				
	30 DAT	**45 DAT**	**60 DAT**	**75 DAT**	**Harvest**
V1	11.58a	18.33a	20.42a	19.25a	16.75a
V2	10.79ab	15.58b	16.83b	16.29b	12.95d
V3	11.13ab	15.21b	16.50b	15.92b	15.03b
V4	10.42b	16.25b	18.17ab	19.71a	14.00c
CV(%)	**7.60**	**10.66**	**14.49**	**11.33**	**5.67**
LSD$_{0.05}$	**0.83**	**1.74**	**2.60**	**2.01**	**0.83**

NB: V1= Beruin,V2= Moinasail,V3=Nagrasail,V4= BRRI dhan49

3.4. Number of tillers hill^{-1} of rice varieties as influenced by plant spacings

3.4.1. Number of tillers hill^{-1} at 30 DAT

Number of tillers hill^{-1} at 30 DAT differed significantly. At 30 DAT the spacing S3 produced the highest number of tiller (12.21 hill^{-1}) which was similar to S4 (11.17 tiller hill^{-1}). The lowest number of tiller (9.83 hill^{-1}) was found in S1 (Table 4).

3.4.2. Number of tillers hill^{-1} at 45 DAT

Number of tillers hill^{-1} at 45 DAT also differed significantly. At 45 DAT the spacing S3 also produced the highest number of tiller (19.17 hill^{-1}) which was significantly different from all others spacings. The closest spacing produced the lowest number of tiller (13.71 hill^{-1}) (Table 4). Moderate number of tiller hill^{-1} was obtained from both the spacing S2 and S3.

3.4.3. Number of tillers hill^{-1} at 60 DAT

Number of tillers hill^{-1} at 60 DAT differed significantly (Table 4) and the results revealed that the spacing S3 had the highest number of tiller (21.63 hill^{-1}) which was followed by the spacing S4. The closest spacing S1 had the lowest number of tiller (13.75 hill^{-1}) and it was significantly different from that of S2 (17.25 hill^{-1}).

3.4.4. Number of tillers hill^{-1} at 75 DAT

Number of tillers hill^{-1} at 75 DAT differed significantly (Tablee 4). At 75 DAT unlike the results of the previous days of interval 40, 50 & 60, the variety BRRI dhan48 gave the highest number of tiller (29.18 hill^{-1}) which was significantly different from the others. Both the varieties BRRI dhan29 and Khoia boro gave moderate number of tillers (26.22 and 23.70 hill^{-1}, respectively) while the local variety Begun bichi gave the lowest (20.22 hill^{-1}).

3.4.5. Number of tillers hill^{-1} at harvest

Number of tillers hill^{-1} at harvest differed significantly (Table 4). The wider spacing S4 produced the highest number of tiller (17.18 hill-1) which was closely followed by S3. The closest spacing S1 produced the lowest number of tiller (11.57 hill-1) while the spacing S2 produced moderate number (13.22 hill-1) It was observed that at harvest tiller hill-1 reduced to some extent might be because of mortality of the tiller at later part of life cycle of rice plant.
Wider spacing produced more tiller hill-1 compared to the closer spacing might be due to availability of more space between the hills.

Table 4. Number of tiller hill^{-1} of T. aman rice varieties as influenced by spacings during T. aman season

Spacing	Mean number of tiller hill^{-1}				
	30 DAT	**45 DAT**	**60 DAT**	**75 DAT**	**Harvest**
S1	9.83c	13.71c	13.75c	13.50c	11.57c
S2	10.71bc	16.25b	17.25b	17.33b	13.22b
S3	12.21a	19.17a	21.63a	21.00a	16.77a
S4	11.17ab	16.25b	19.29ab	19.33ab	17.18a
CV(%)	**11.88**	**15.21**	**17.40**	**16.84**	**4.62**
$LSD_{0.05}$	**1.10**	**2.09**	**2.64**	**2.54**	**0.57**

NB: S1=15 cm x 15 cm, S2=20 cm x 15 cm, S3=20 cm x 20 cm, S4= 20 cm x 25 cm.

3.5. Yield components and yield

3.5.1. Performance of rice cultivers

3.5.1.1. Tillers hill^{-1}

Results revealed that both number of effective and percent non-effective tillers hill^{-1} studied in the experiment differed significantly among the rice varieties (Table 5). The variety V1 (Beruin) produced the highest number of effective tillers 16.8 hill^{-1} while V4 (BRRI dhan49) produced the lowest 12.0 hill^{-1}. Per cent non-effective tiller hill^{-1} was found the highest 18.9 hill^{-1} in V4 (BRRI dhan49) and the lowest 11.6 hill^{-1} in V3 (Nagrasail). The results indicated that percent non- effective tiller hill^{-1} was comparatively lower in all the local varieties.

3.5.1.2. Spikelets panicle^{-1}

Both filled and percent unfilled spikelets panicle^{-1} differed significantly among the varieties (Table 5). The highest number of filled spikelet 73.1 panicle^{-1} was recorded form the variety V4 which was significantly different from all other varieties. The lowest number of filled spikelet 46.9 panicle^{-1} was recorded from the variety V1 which was also significantly different from all others. The varieties V2 and V3 recorded statistically at par numbers 54.8 and 58.9 of filled spikelets panicle^{-1} respectively. The variety V3 had the lowest percent 15.6 of unfilled spikelet panicle^{-1} while V4 had the highest percent of unfilled spikelet 38.4 panicle^{-1}. The varieties V1 and V2 had 21.6 and 18.9 percent unfilled spikelet panicle^{-1} respectively which was significantly different from all other varieties. The results revealed that the HYV BRRI dhan49 had the highest percent of unfilled spikelet panicle^{-1} might be due to low temperature occur in November during flowering because of late planting in the month of September.

Table 5. Yield attributes and yield of rice varieties irrespective of plant spacing

Variety	Tillers hill^{-1}		Spikelets panicle^{-1}		1000-grain weight (g)	Grain yield (tha^{-1})
	Effective (no.)	Non-effective (%)	Filled (no.)	Unfilled (%)		
V1	16.8a	15.6b	46.9c	21.6b	22.58a	1.81b
V2	12.9c	16.7ab	54.8b	18.9c	21.95ab	1.79b
V3	15.0b	11.6c	58.9b	15.6d	21.95ab	2.60a
V4	14.0c	18.9a	73.1a	38.4a	19.90c	2.65a
CV(%)	5.66	14.13	9.37	8.25	6.16	7.00
LSD 0.05	0.83	2.22	5.47	1.95	1.31	0.15

Note: V1= Beruin, V2= Moinasail, V3= Nagrasail, V4= BRRI dhan49 (Control); Figures in the same colmn having dissimilar letter(s) differed significantly at 5% level of probability

3.5.1.3. 1000-grain weight

Thousand grains weight also differed significantly among the varieties (Table 5). The variety V1 produced the highest 1000-grain weight of 22.58 g which was statistically similar to that of V2 and V3 of 21.95 g each. The variety V4 produced the lowest 1000-grain weight of 19.90 g which was significantly different from all other treatments. The results showed that the variety V1 had comparatively coarse grain than other two local varieties of V2 (Moinasail) and V3 (Nagrasail).

3.5.1.4. Grain yield

The highest grain yield of 2.65 t ha^{-1} was obtained from the variety V4 (BRRI dhan49) which was statistically at par with that of V3 (local- Nagrasail) of 2.60 t ha^{-1} (Table 5). The lowest grain yield of 1.79 t ha^{-1} was obtained from the variety V2 which was also statistically at par with that of 1.81 t ha^{-1}of V1. Grain yield of each variety was attributed by the number of effective tiller hill^{-1}, number of filled grains panicle^{-1} and 1000-grain weight. In V4 grain yield was mainly compensated by the highest number of filled grain 73.1 panicle^{-1} in spite of lower number of effective tillers 14.0 hill^{-1} and smaller grain size of 19.90 g 1000-grain weight.

3.5.2. Effect of spacing

3.5.2.1. Tillers hill^{-1}

Both effective and non-effective tillers hill^{-1} differed significantly due to variation in the plant spacing

(Table 6). The spacing S4 produced the highest number of effective tillers 16.7 hill^{-1}statistically at par with that of 16.3 hill^{-1} of the spacing S3. The highest percent of 18.2 non- effective tiller hill^{-1} was recorded from the spacing S1while the lowest percent of 14.3 non- effective tiller hill^{-1}was recorded from the spacing S4. Both the spacing S2 and S3 produced percent non-effective tillers 15.6 and 14.8 hill^{-1} statistically at par with that of S4. The results indicated that wider spacing had lower percent of non-effective tillers hill^{-1}. Dense population had more non-effective tillerhill^{-1}.

3.5.2. 2. Spikelets panicle^{-1}

Both filled and unfilled spikelets panicle^{-1} differed significantly among the spacing (Table 6). Filled spikelets panicle^{-1} increased with increasing of spacing. The results revealed that the highest number 67.8 of filled grains panicle^{-1} was found in S3which was statistically at par with that of number of 62.0 of filled grains panicle^{-1}found in S4. The lowest number 54.4 of filled grains panicle^{-1} was found in the spacing S1 at par with that of 54.7 at the spacing S2.Unlike filled spikelets panicle^{-1} percent unfilled spikelets panicle^{-1} decreased with the increase of plant spacing. The lowest percent 21.7 of unfilled spikelet panicle^{-1} was found in the widest spacing S4 whilst the highest percent 26.4 was found at the closest spacing S1. This indicates that more spikelets unit^{-1} area beyond the optimum number failed to supply photosynthates to the sink. As a result, a number of spikelet remained unfilledpanicle^{-1}.

3.5.2. 3. 1000-grain weight

Different spacing exerted significant influence on 1000-grain weight (Table 2). Wider spacing S3 and S4 gave statistically at par 1000-grain weight of 22.33 and 22.43 g respectively. Thousand-grain weight of S3 and S4 was significantly different from the other spacing of S1 and S2. The lowest 1000-grain weight of 19.08 g was found in the spacing S1 and spacing S2 had moderate 1000-grain weight of 21.25 g. The results revealed that in case of fewer numbers of grains, increased assimilate supply and more dry matter accumulate in individual grain compared to higher number per unit area.

3.5.2. 4. Grain yield

The spacing S4 produced the highest grain yield of 2.35 t ha^{-1} which was statistically similar to that of 2.29 t ha^{-1} of S3 (Table 2). The lowest grain yield of 1.99 t ha^{-1} was produced by the spacing S1 which was significantly different from all other spacing. Grain yield of the spacing S2 was 2.20 t ha^{-1} which was statistically similar to that of the spacing S3. Higher number of effective tillers hill^{-1}, filled spikelets panicle^{-1} and higher 1000-grain weight in the spacing S3 and S4 accredited to produce more grain yield. The plants under wider spacing anticipated more favourable condition for their growth and development. There was less competition for nutrients, light and water among the plants compared to closer plant spacing of S1 and S2.

Table 6. Yield attributes and yield as influenced by plant spacing irrespective of rice varieties

Plant spacing	Tillers hill^{-1}		Spikelets panicle^{-1}		1000-grain weight (g)	Grain yield (tha^{-1})
	Effective (no.)	Non-effective (%)	Filled (no.)	Unfilled (%)		
S1	11.1c	18.2a	54.4b	26.4a	19.08c	1.99c
S2	12.7b	15.6b	54.7b	23.3b	21.25b	2.20b
S3	16.3a	14.8b	62.7a	23.3b	22.33a	2.29ab

S4	16.7a	14.3b	62.0a	21.7c	22.43a	2.35a
CV(%)	4.62	10.54	8.74	7.33	3.30	6.35
$LSD_{0.05}$	0.57	1.39	4.30	1.46	0.59	0.12

Note: S1= 15 cm × 15 cm, S2= 20 cm × 15 cm, S3= 20 cm × 20 cm, S4= 20 cm ×25 cm

3.6. Interaction effects

All characters studied in the experiment showed significant difference due to the interaction effect between variety and plant spacing. These are described below.

3.6.1. Tillers hill^{-1}

The results revealed that local variety V1 produced the highest same number 19.3 of effective tiller hill^{-1} at both spacing S3 and S4 (Table 7). The lowest number 9.3 of effective tillers hill^{-1} was produced by the variety V2 at the spacing S1 (V2×S1). Each and every variety showed the increasing trend of effective tillers hill^{-1}with the increasing of plant spacing. The interaction V2×S1 produced the highest 21.3 percent of non-effective tiller hill^{-1} followed by the interaction V2×S2, V4×S1 and V4×S4 (20.2, 19.9 and 19.9 % non-effective tiller hill^{-1}respectively).

3.6.2. Spikelets panicle^{-1}

The highest 82.3number of filled spikelets panicle^{-1} was recorded in the variety V4 at the spacing S3 (V4×S3) which was closely followed by 78.5 number of filled spikelets panicle^{-1} by the same variety at S4 (V4×S4). In most cases number of filled spikelet panicle^{-1} increased with wider spacing. The interaction V1×S3 produced the lowest 41.9 number of filled spikelets panicle^{-1}. There was no consistency in respect of producing the percent of unfilled spikelets panicle^{-1}. The highest percent 44.83 of unfilled spikelets panicle^{-1}was recorded from the interaction of V4×S4 which was followed by the percent 39.43 in the interaction of V4×S1. The lowest percent 10.97 of unfilled spikelet panicle^{-1} was found in the interaction V3×S3.

3.6.3. 1000-grain weight(g)

The results revealed that the local variety V1 (Beruin) with the spacing S4 produced the highest 1000-grain weight of 24.62 g similar to that of S3 of the same variety (24.53 g). All varieties produced higher 1000-grain weight i.e. larger seed size with the wider spacing. The lowest 1000-grain weight of 17.81 g was obtained from the HYV BRRI dhan49 with the spacing S1. Shading effects of inter- and intra-plant may reduce the photosynthesis and building more competition among the plants for nutrient supply from soil resulted small sized grain in the narrower spacing. Better light penetration as well as photosynthesis and supply of more nutrients among the population resulted heavier grain in the wider spacing.

3.6.4. Grain yield

Grain yield was also varied significantly due to interaction of variety and spacing (Table 7). It was found that the V4 (BRRI dhan49) produced the highest grain yield of 2.87 t ha^{-1} along with the spacing S4 (V4 x S4) which was statistically similar to that of the combinations of V4× S3, V4× S2, V3 × S4 and V3× S3

(2.72, 2.68, 2.64 and 2.65 t ha^{-1} respectively). Higher grain yield was ascribed to the higher number of effective tiller $hill^{-1}$ and larger grain size. The lowest grain yield 1.58 t ha^{-1} was obtained from the interaction of V1×S1. This was statistically at par with that of V1×S2, V1×S3, V2×S1, V2×S2 and V2×S4.

Table 7. Yield attributes and yield of rice varieties as influenced by the interaction of rice varieties and spacing

Interaction (V x S)	Tillers hill^{-1}		Spikelets panicle^{-1}		1000-grain weight (g)	Grain yield (t ha^{-1})
	Effective (no.)	Non-effective (%)	Filled (no.)	Unfilled (%)		
V1×S1	13.5e	18.0bc	46.5gh	21.87e	18.06h	1.58g
V1×S2	14.9d	15.4cd	50.1gh	17.70g	23.13b	1.77g
V1×S3	19.3a	19.0ab	41.9h	29.13d	24.53a	1.76g
V1×S4	19.3a	10.2gh	49.3gh	17.53g	24.62a	2.11ef
V2×S1	9.3h	21.3a	51.1g	23.37e	21.52de	1.61g
V2×S2	11.6g	20.2ab	52.2g	27.30d	21.84cde	1.73g
V2×S3	14.9d	10.9fgh	62.5cde	13.13h	22.40bcd	2.03f
V2×S4	16.0bcd	14.4de	53.5fg	12.13h	22.04bcd	1.77g
V3×S1	11.9fg	13.5def	50.0gh	20.90ef	18.94gh	2.48cd
V3×S2	13.5e	8.8h	54.9efg	12.30h	20.05fg	2.61bc
V3×S3	16.5b	11.5fgh	63.9cd	10.97h	22.78bc	2.65abc
V3×S4	18.2a	12.4efg	66.8cd	18.03fg	20.83ef	2.64abc
V4×S1	11.6g	19.9ab	70.1bc	39.43b	17.81h	2.30de
V4×S2	12.9ef	18.1bc	61.5def	35.80c	19.97fg	2.68abc
V4×S3	16.3bc	17.9bc	82.3a	33.47c	19.61g	2.72ab
V4×S4	15.2cd	19.9ab	78.5ab	44.83a	22.22bcd	2.87a
CV(%)	4.62	10.54	8.74	7.33	3.30	6.35
LSD 0.05	1.14	2.79	8.61	2.92	1.18	0.24

Figures in a column with same letter(s) did not differ significantly at 5% level of significant; V1= Beruin; V2= Moinasail; V3=Nagrasail; V4=BRRI dhan49; S1= 15cm × 15cm, S2= 20cm × 15cm, S3= 20cm × 20cm, S4= 20cm ×25cm

4. Conclusion

The results obtained in the experiment indicated that the local variety Nagrasail performed better than other local. It may be suggested to grow Nagrasail with wider spacings of 20cm × 20cm & 20cm × 25cm to obtain higher grain yield. Whilst the local variety Beruin and Moinasail still interested to grow the farmers in Sylhet region may cultivate with 20cm × 25cm and the variety Moinasail may cultivate with the spacing 20cm × 20cm for obtaining higher grain yield.

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