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EFFECT OF NUMBER OF SEEDLINGS *PER* HILL AND SPACING ON GROWTH AND YIELD OF TRANSPLANTED *AMAN* RICE (Var. Ranisalute)

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Abstract: A field experiment was conducted with a view to examining the effect of number of seedlings hill^{-1} and spacing of planting on the growth and yield of transplanted *aman* rice (*var.* Ranisalute). The experiment consisted of five different number of seedlings hill^{-1} *viz.* 2, 3, 4, 5 and 6 and three plant spacing *viz.* 50 cm × 50 cm, 40 cm × 40 cm and 30 cm × 30 cm. The experiment was laid out in a factorial randomized complete block design with three replications. Individually number of seedlings hill^{-1} and spacing had no significant effect on growth and yield components. Numerically the highest grain yield and harvest index was obtained from 6 seedlings hill^{-1} and of 30 cm × 30 cm spacing separately. There were significant variation in the interaction effect of seedling hill^{-1} with spacing on the yield components except panicle length and 1000-grain weight. Among the interactions 3 seedlings hill^{-1} with 30 cm × 30 cm spacing produced the highest grain yield and harvest index, the uppermost straw yield and biological yield was obtained from 2 seedlings with 30 cm × 30 cm spacing and maximum grain panicle^{-1} was produced by 2 seedlings with 40 cm × 40 cm spacing.

Keywords: Aman, Ranisalute, spacing of seedlings, growth and yield of *aman.*

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crop of the world. It is the staple food of about 160 million people of Bangladesh. It provides nearly 48% of rural employment, about 2/3rd of total calorie supply and about half of the total protein intake of an average person in the country. Rice sector contributes half of the agricultural GDP and 1/6th of the national income in Bangladesh (BRRI, 2007). The dominant food crop of Bangladesh is rice; accounting for about 75% of agricultural land use. Agriculture in Bangladesh is predominantly rice based and Bangladesh is the fourth rice producing country in the world. The total area and production of rice in Bangladesh are 11.38 million hectare and 34.356 million ton, respectively (BBS, 2014).

Since long, people of Bangladesh had been cultivating local varieties of rice applying their own technique but poverty, rainfall pattern, scarcity of fresh irrigation water and shrinking of arable land compelled them to cultivate high yielding varieties of rice in order to meet their need as well as to make it surplus. But local rice varieties for their nutrition

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value, taste and high tolerance to various adverse conditions are important for cultivation. In a developing country like Bangladesh now the farmers are very much interested to grow genetically modified (GM) varieties of rice, which are aimed at producing more food. But, if we want to develop GM varieties of rice local varieties are important because they are great source of different valuable genes such as salt tolerant gene, disease and insect resistance gene, drought and frost resistance gene, etc. The traditional rice varieties possess several stress tolerant properties. Such properties act as positive factors in the retention of the primitive rice varieties in the face of the increasing propaganda for cultivation of high yielding rice varieties (Das and Das, 2014).

Most of the farmers in our country cultivate rice by means of traditional cultivation practices without considering modern concepts such as spacing of transplanting, number of seedlings used hill^{-1}, actual rate of fertilizers, time and method of fertilizers application etc. Among the different management practices, use of appropriate number of seedlings hill^{-1} and spacing are important. Optimum plant density ensures the plant grow properly with their aerial and underground parts by utilizing more solar radiation and soil nutrients (Miah *et al.,* 1990). When the planting density exceeds the optimum level, competition among plants for light above ground or for nutrients below the ground becomes severe and consequently the plant growth slows down and the grain yield decreases. On the other hand, wider space allows the individual plant to produce more tillers but it provides smaller number of hills unit^{-1} area which results in low grain yield (Baloch *et al*., 2002). Alam (2006) stated that optimum spacing gave a maximum number of total tillers m^{-2} and maximum number of fertile tillers m^{-2} which were dependent on temperature, moisture and other soil factors. Number of seedlings hill^{-1} is an important factor for successful rice production because it affects plant population unit^{-1} area, availability of sunlight and nutrients, photosynthesis and respiration, which ultimately influence the yield contributing characters and yield (Chowdhury *et al.,* 1993). Nakano and Mizushima (1994) reported that grain yield is negatively correlated with increasing the number of seedling hill^{-1}. Alam (2006) reported that the highest number of total tillers and number of effective tillers were obtained from two seedlings hill^{-1}. Obulamma and Reddeppa (2002) reported that one seedling hill^{-1} gave the highest grain yield, crop growth rate and net assimilation rate while three seedlings hill^{-1} had the highest dry matter production, leaf area index and leaf area density. Therefore, the present study was conducted to examine the effect of number of seedlings hill^{-1} and spacing on the growth and yield attributes of local transplanted aman rice (*var.* Ranisalute).

Materials and Methods

The experiment was conducted in the experimental field of Khulna University during the *Aman* season from August 2015 to January 2016. There were five different number of seedlings hill^{-1} *viz.* 2, 3, 4, 5 and 6 and three plant spacing's *viz.* 50 cm × 50 cm, 40 cm × 40 cm and 30 cm × 30 cm. The experiment was laid out in a factorial randomized compete block design with three replications. There were 45 plots altogether- 15 plots in each replication. The size of a plot was 4.0 m × 2.5 m. Seeds of Ranisalute were collected from a farmer of Batiaghata upazila of Khulna district. Seedlings were raised in wet seedbed with proper care. Plots were prepared and uniformly fertilized with Urea, TSP, MoP, Gypsum and Zinc Sulphate @ 180, 100, 70, 60 and 10 kg ha^{-1} respectively (recommendation dose for

the area). Half of urea and full dose of TSP, MoP, Zinc Sulphate and Gypsum were applied during final land preparation and incorporated with the soil. Rest of the urea was top dressed in three equal splits at 20, 45 and 60 days after transplanting. The seedlings were uprooted carefully when they were 30 days old and were kept in soft mud under shade and transplanted on 1st September 2015 with number of seedlings hill^{-1} as specified in the treatment. The seedlings were transplanted carefully maintaining the spacing as per treatment specification. Intercultural operations were done as and when necessary. The whole plots were harvested at their full maturity stage to obtain grain and straw yield. Threshing was done manually. Grains and straw were cleaned and adjusted at 14% moisture content. Parameters such as, plant height, number of tillers hill^{-1}, number of effective tillers hill^{-1}, panicle length, number grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, biological yield and harvest index were estimated and analyzed with the help of MSTAT-C and Duncan's New Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Plant height: Number of seedlings hill^{-1} and spacing had no significant effect on plant height at different dates after transplanting. Apparently at harvest the tallest (133.00 cm) and the shortest (126.78 cm) plants were observed in 5 seedlings and 2 seedlings hill^{-1}, respectively (Table 1). The results are similar to the findings of Hushine (2004), Shrirame *et al.* (2000) and Zhang and Huang (1990), who reported that plant height was not significantly affected by seedlings hill^{-1}. The results are in contradictory with that of Hasanuzzaman *et al.* (2013), Miah *et al.* (1990) and Shah *et al.* (1991), who stated that plant height increased with decrease in seedling number hill^{-1} whereas Singh (1981) showed that plant height increased with increasing number of seedlings hill^{-1}.

Table 1: Effect of number of seedlings hill^{-1} on the plant height of transplanted *aman* rice (*var.* Ranisalute)

Seedling hill^{-1}	Plant height (cm)						
	30 DAT	*45 DAT*	*60 DAT*	*75 DAT*	*90 DAT*	*105 DAT*	*At harvest*
2 (T_1)	78.50	87.88	103.71	121.44	122.67	124.56	126.78
3 (T_2)	81.78	92.53	110.11	124.44	125.00	127.11	128.78
4 (T_3)	82.87	93.99	106.11	122.22	123.67	125.67	128.00
5 (T_4)	80.53	93.82	109.89	128.78	129.33	131.00	133.00
6 (T_5)	80.82	91.70	108.44	123.00	124.89	127.00	129.11
Level of significance	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.74	5.40	5.08	4.74	4.13	3.74	3.57

NS = Not significant
CV= Coefficient of variation

At harvest apparently the tallest plant (129.27 cm) was obtained from 30 cm × 30 cm spacing and the shortest plant (128.93) from 50 cm × 50 cm spacing (Table 2). Combination of seedlings hill^{-1} and spacing exerted significant influence at 30 DAT, 60 DAT and 75 DAT but did not show any significant influence on plant height at 45 DAT, 90 DAT, 105 DAT and at harvest (Table 3).

Table 2: Effect of spacing on the plant height of transplanted *aman* rice (*var.* Ranisalute)

Spacing of planting	Plant height (cm)						
	30 DAT	*45 DAT*	*60 DAT*	*75 DAT*	*90 DAT*	*105 DAT*	*At harvest*
50 cm×50 cm (S_1)	80.85	91.99	106.53	123.53	124.80	126.73	128.93
40 cm×40 cm (S_2)	80.17	91.35	106.96	123.73	125.33	127.20	129.20
30 cm×30 cm (S_3)	81.68	92.61	109.47	124.67	125.20	127.27	129.27
Level of significance	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.74	5.40	5.08	4.74	4.13	3.74	3.57

NS = Not significant
CV= Coefficient of variation

Table 3: Interaction effect of number of seedlings hill^{-1} and spacing on plant height of transplanted *aman* rice (*var.* Ranisalute)

Interaction (T×S)	Plant height (cm)						
	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	At harvest
$T_1×S_1$	80.03ab	87.03	104.00bc	120.33ab	122.33	123.67	126.33
$T_1×S_2$	76.80b	88.13	100.80c	119.67b	122.00	124.00	126.00
$T_1×S_3$	78.67ab	88.47	106.33abc	124.33ab	123.67	126.00	128.00
$T_2×S_1$	84.73a	94.60	108.67abc	127.33ab	126.33	128.33	130.00
$T_2×S_2$	78.80ab	90.30	109.00abc	123.00ab	124.67	126.67	128.33
$T_2×S_3$	81.80ab	92.70	112.67ab	123.00ab	124.00	126.33	128.00
$T_3×S_1$	83.57ab	93.20	106.33abc	121.67ab	123.00	125.00	127.33
$T_3×S_2$	83.77ab	94.17	106.67abc	122.33ab	124.00	126.00	128.33
$T_3×S_3$	81.27ab	94.60	105.33abc	122.67ab	124.00	126.00	128.33
$T_4×S_1$	75.87b	92.70	105.33abc	124.33ab	126.67	128.67	130.67
$T_4×S_2$	80.80ab	92.23	108.67abc	130.00ab	129.67	131.33	133.33
$T_4×S_3$	84.93a	96.53	115.67a	132.00a	131.67	133.00	135.00
$T_5×S_1$	80.03ab	92.43	108.33abc	124.00ab	125.67	128.00	130.33
$T_5×S_2$	80.70ab	91.90	109.67abc	123.67ab	126.33	128.00	130.00
$T_5×S_3$	81.73ab	90.77	107.33abc	121.33ab	122.67	125.00	127.00
Level of significance	*	NS	*	*	NS	NS	NS
CV (%)	4.74	5.40	5.08	4.74	4.13	3.74	3.57

Mean values in a column having similar letter (s) or without letters (s) do not differ significantly as per DMRT.
NS = Not significant
* = Significant at 5% level
CV= Coefficient of variation

T_1 = 2 seedlings hill^{-1}
T_2 = 3 seedlings hill^{-1}
T_3 = 4 seedlings hill^{-1}
T_4 = 5 seedlings hill^{-1}
T_5 = 6 seedlings hill^{-1}

S_1 = 50 cm x 50 cm spacing
S_2 = 40 cm x 40 cm spacing
S_3 = 30 cm x 30 cm spacing

Total Number of tillershill^{-1}: Number of tiller shill^{-1} was not significantly affected by number of seedlings hill^{-1} and spacing. The maximum number of tillers (24.47) was observed from 5 seedlings hill^{-1} almost all dates after transplanting of plant growth whereas the lowest number of total tillers (20.38) was observed from 2 seedlings hill^{-1} (Table 4). The results are in contradictory with Shieh (1979), Ayub *et al*., (1987) and Mian *et al*., (1970) who reported that number of total tillers hill^{-1} was significantly influenced on number of seedling hill^{-1}. At harvest the highest number of total tillers (23.31) was obtained from 50 cm × 50 cm spacing and the lowest tiller number (22.68) was obtained from 30 cm × 30 cm spacing (Table 5). The results are similar to the findings of Hasanuzzaman *et al*., (2009), who stated that number of total tillershill^{-1} was not significantly influenced by plant spacing. Interaction effect had significant influence on the number of total tillershill^{-1} at 30 DAT, 45 DAT, 60 DAT and 75 DAT but did not show any significant influence on number of total tillers hill^{-1} at 90 DAT, 105 DAT and at harvest (Table 6). At harvest maximum number of total tillers hill^{-1} (31.60) was obtained from $T_4 \times S_3$ treatment combination while the minimum number of total tillers hill^{-1}(19.07) was obtained from $T_1 \times S_3$ treatment combination.

Table 4: Effect of number of seedlings hill^{-1} on the number of total tillers of transplanted *aman* rice (*var.* Ranisalute)

Seedling hill^{-1}	Total tillers hill^{-1}(no)						
	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	At harvest
2 (T_1)	8.18	18.18	22.36	24.56	22.36	20.42	20.38
3 (T_2)	9.58	20.71	25.11	27.78	26.27	24.40	24.20
4 (T_3)	10.87	22.07	27.58	29.04	25.31	23.13	22.93
5 (T_4)	11.20	22.51	26.73	28.93	27.40	24.67	24.47
6 (T_5)	11.40	20.60	25.44	28.27	24.78	23.27	23.16
Level of significance	NS	NS	NS	NS	NS	NS	NS
CV (%)	19.88	19.18	13.27	11.54	14.26	14.05	13.90

NS = Not significant
CV= Coefficient of variation

Table 5: Effect of spacing of planting on the number of total tillers hill^{-1} of transplanted *aman* rice (*var.* Ranisalute)

Spacing of planting	Total tillers hill^{-1}(no)						
	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	At harvest
50 cm × 50 cm (S_1)	9.63	20.67	25.32	28.03	25.56	23.47	23.31
40 cm × 40 cm (S_2)	10.11	20.03	24.28	26.95	25.21	23.28	23.09
30 cm × 30 cm (S_3)	11.00	21.75	26.73	28.17	24.89	22.79	22.68
Level of significance	NS	NS	NS	NS	NS	NS	NS
CV (%)	19.88	19.18	13.27	11.54	14.26	14.05	13.90

NS = Not significant
CV= Coefficient of variation

Table 6: Interaction effect of number of seedlings hill^{-1} and spacing on the total number of tillers hill^{-1} of transplanted *aman* rice (*var.* Ranisalute)

Interaction (T×S)	Total tillers hill^{-1}(no)						
	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	At harvest
$T_1 \times S_1$	7.87cd	18.40ab	22.67bcd	25.07bcd	21.60	20.53	20.47
$T_1 \times S_2$	7.40d	17.20ab	21.33cd	24.53bcd	24.07	21.67	21.60
$T_1 \times S_3$	9.27abcd	18.93ab	23.07bcd	24.07cd	21.40	19.07	19.07
$T_2 \times S_1$	9.13abcd	21.67ab	27.00abcd	29.07abcd	27.33	24.93	24.60
$T_2 \times S_2$	8.53bcd	16.53b	20.33d	23.67d	23.33	22.80	22.53
$T_2 \times S_3$	11.07abcd	23.93ab	28.00abc	30.60abc	28.13	25.47	25.47
$T_3 \times S_1$	10.13abcd	21.80ab	26.87abcd	28.87abcd	25.53	23.27	23.13
$T_3 \times S_2$	12.87a	24.07ab	28.80ab	31.00ab	25.93	23.33	23.27
$T_3 \times S_3$	9.60abcd	20.33ab	27.07abcd	27.27abcd	24.47	22.80	22.40
$T_4 \times S_1$	9.13abcd	19.80ab	24.00abcd	26.93abcd	25.87	23.13	23.00
$T_4 \times S_2$	11.60abcd	22.93ab	25.53abcd	26.67abcd	27.73	25.20	24.80
$T_4 \times S_3$	12.87a	24.80 a	30.67a	33.20a	32.60	32.00	31.60
$T_5 \times S_1$	11.87abc	21.67ab	26.07abcd	30.20abcd	27.47	25.47	25.33
$T_5 \times S_2$	10.13abcd	19.40ab	25.40abcd	28.87abcd	25.00	23.40	23.27
$T_5 \times S_3$	12.20ab	20.73ab	24.87abcd	25.73bcd	21.87	20.93	20.87
Level of significance	*	*	*	*	NS	NS	NS
CV (%)	19.88	19.18	13.27	11.54	14.26	14.05	13.90

NS = Not significant
CV= Coefficient of Variation

T_1 = 2 seedlings hill^{-1}
T_2 = 3 seedlings hill^{-1}
T_3 = 4 seedlings hill^{-1}
T_4 = 5 seedlings hill^{-1}
T_5 = 6 seedlings hill^{-1}

S_1 = 50 cm x 50 cm spacing
S_2 = 40 cm x 40 cm spacing
S_3 = 30 cm x 30 cm spacing

Number of effective tillers hill^{-1}: Number of effective tillers hill^{-1} was not significantly affected by number of seedlings hill^{-1} and spacing. 4 seedlings hill^{-1} produced highest number of effective tillers hill^{-1} (23.04) and the lowest number of effective tillers hill^{-1} was produced by 2 seedlings hill^{-1} (21.29) (Table 7).

Table 7: Effect of number of seedlings hill^{-1} on the yield and yield attributes of transplanted *aman* rice (*var.* Ranisalute)

Seedling hill^{-1}	Effective tillers hill^{-1} (no)	Panicle length (cm)	Grains panicle^{-1} (no)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
2 (T_1)	21.29	25.98	80.73	37.11	2.15	4.64	6.79	32.62
3 (T_2)	22.40	25.82	77.87	34.39	2.23	4.46	6.69	32.69
4 (T_3)	23.04	25.97	66.80	37.28	1.84	4.53	6.37	29.77
5 (T_4)	22.44	25.57	69.73	35.06	2.00	4.38	6.39	31.43
6 (T_5)	22.53	26.07	73.16	36.39	2.25	4.52	6.77	33.16
Level of significance	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	18.39	4.57	13.74	8.38	27.67	24.81	23.46	14.30

NS = Not significant
CV= Coefficient of variation

The results are similar to the findings of Islam *et al.*, (2012), who observed that number of effective tillers hill^{-1} was not significantly affected by number of seedlings hill^{-1}. The closest spacing 30 cm x 30 cm produced highest number of effective tillers hill^{-1} (23.11) and 40 cm x 40 cm spacing produced lowest number of effective tillers hill^{-1} (21.63) (Table 8). Interaction effect had significant influence on the number of effective tillers hill^{-1}. The highest number of effective tillers (28.13) was produced from $T_4 \times S_3$ and the lowest number of effective tillers (18.53) was produced from $T_2 \times S_2$ treatment combination (Table 9). The results are similar to the findings of Hasanuzzaman *et al.* (2009)., who observed that interaction effect of spacing and number of seedlings hill^{-1} show significant influence on number of effective tillers hill^{-1}.

Table 8: Effect of spacing on the yield and yield attributes of transplanted *aman* rice (*var.* Ranisalute)

Spacing of planting	Effective tillers hill^{-1} (no)	Panicle length (cm)	Grains panicle^{-1} (no)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
50 cm×50 cm(S_1)	22.29	25.80	73.24	36.33	1.59	3.51	5.09	31.29
40 cm×40 cm(S_2)	21.63	26.12	78.49	35.07	2.15	4.58	6.72	31.67
30 cm×30 cm(S_3)	23.11	25.72	69.24	36.73	2.56	5.44	7.99	32.83
Level of significance	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	18.39	4.57	13.74	8.38	27.67	24.81	23.46	14.30

NS = Not significant,
CV= Coefficient of variation

Table 9: Interaction effect of number of seedlings hill^{-1} and spacing on the yield and yield attributes of transplanted *aman* rice (var. Ranisalute)

Interaction (T×S)	Effective tillers hill^{-1} (no)	Panicle length (cm)	Grains panicle^{-1} (no)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
$T_1 \times S_1$	19.73ab	26.47	75.00ab	38.50	1.57ab	3.18c	4.75d	33.00ab
$T_1 \times S_2$	23.13ab	26.57	90.80a	38.50	2.41ab	4.66abc	7.08abcd	34.43ab
$T_1 \times S_3$	21.00ab	24.90	76.40ab	34.33	2.48ab	6.07a	8.54a	30.43ab
$T_2 \times S_1$	23.80ab	25.57	78.87ab	34.00	1.56ab	3.72bc	5.28bcd	29.47ab
$T_2 \times S_2$	18.53b	26.93	82.67ab	34.50	1.95ab	4.50abc	6.45abcd	30.27ab
$T_2 \times S_3$	24.87ab	24.97	72.07ab	34.67	3.19a	5.16abc	8.34ab	38.33a
$T_3 \times S_1$	22.73ab	26.13	72.40ab	38.17	1.39b	3.71bc	5.11cd	27.30b
$T_3 \times S_2$	25.53ab	25.37	65.93b	34.83	2.15ab	4.76abc	6.91abcd	30.37ab
$T_3 \times S_3$	20.87ab	26.40	62.07b	38.83	1.98ab	5.11abc	7.09abcd	31.63ab
$T_4 \times S_1$	19.93ab	25.13	67.00b	35.83	1.76ab	3.27c	5.03cd	35.20ab
$T_4 \times S_2$	19.27b	25.50	78.00ab	32.00	1.96ab	4.15abc	6.11abcd	31.63ab
$T_4 \times S_3$	28.13a	26.07	64.20b	37.33	2.29ab	5.73ab	8.02abc	27.47b
$T_5 \times S_1$	25.27ab	25.70	72.93ab	35.17	1.66ab	3.63bc	5.29bcd	31.50ab
$T_5 \times S_2$	21.67ab	26.23	75.07ab	35.50	2.25ab	4.80abc	7.05abcd	31.67ab
$T_5 \times S_3$	20.67ab	26.27	71.47ab	38.50	2.85ab	5.14abc	7.96abc	36.30ab
Level of significance	*	NS	*	NS	**	*	*	*
CV (%)	18.39	4.57	13.74	8.38	27.67	24.81	23.46	14.30

NS = Not significant
CV= Coefficient of variation,
* = Significant at 5% level, ** = Significant at 1% level

T_1 = 2 seedlings hill^{-1}
T_2 = 3 seedlings hill^{-1}
T_3 = 4 seedlings hill^{-1}
T_4 = 5 seedlings hill^{-1}
T_5 = 6 seedlings hill^{-1}

S_1 = 50 cm x 50 cm spacing
S_2 = 40 cm x 40 cm spacing
S_3 = 30 cm x 30 cm spacing

Panicle length: Number of seedlings hill^{-1}, spacing and interaction of seedling numbers and spacing did not affect panicle length significantly. The longest (26.07 cm) and shortest (25.57 cm) panicle lengths were observed in 6 and 5 seedlings hill^{-1}, respectively (Table 7). The results are in conformity with Hasanuzzaman *et al.* (2009), Islam *et al.* (2008), Hushine (2004), BRRI (1999), Zhang and Huang (1990), who stated that panicle length was unaffected by the number of seedlings hill^{-1}. Numerically the longest panicle (26.12 cm) was produced by 40 cm × 40 cm spacing while the shortest one (25.72 cm) was produced by closest spacing 30 cm × 30 cm (Table 8). Numerically the longest panicle (26.93 cm) was produced by $T_2 \times S_2$ while the shortest one (24.90 cm) was produced by $T_1 \times S_3$ (Table 9). The

results are similar to the findings of Islam *et al.*, (2012), who stated that interaction among hill density and no. of seedlings hill^{-1} did not show significance effect on panicle length.

Grain panicle^{-1}: Number of grains panicle^{-1} was not significantly influenced by the number of seedlings hill^{-1}and spacing. The highest (80.73) and lowest (66.80) number of grains panicle^{-1} were obtained with 2 and 4 seedlings hill^{-1}, respectively. The highest (78.49) and lowest (69.24) number of grains panicle^{-1} was obtained with 40 cm × 40 cm (S_2)and 30 cm × 30 cm spacing, respectively (Table 8). Number of grain panicle^{-1} was significantly affected by the interaction effect of number of seedlings hill^{-1} and spacing. The highest number of grains panicle^{-1} (90.80) was obtained with the treatment combination of $T_1 \times S_2$ and lowest number of grains panicle^{-1} (62.07) was obtained with the treatment combination of $T_3 \times S_3$ (Table 9). The results are similar to the results of Bhowmik *et al.* (2012), who stated that the interaction effect of spacing and number of seedlings hill^{-1} had significant effect on the number of grains panicle^{-1}.

Weight of 1000- grains: Weight of 1000-grains was not significantly affected by number of seedlings hill^{-1} and spacing. 4 seedlings hill^{-1} produced highest weight of 1000-granis (37.28 g) and 3 seedlings hill^{-1} produced the lowest weight of 1000-granis (34.39 g) (Table 7). The results are similar to the findings of Islam *et al.* (2012), and Mahamud *et al.* (2013), who stated that the weight of 1000-grains was not significantly influenced by the number of seedlings hill^{-1}. 1000-grains weight was more (36.73 g) in closer spacing 30 cm × 30 cm (S_3) whereas the grain weight was less (35.07 g) at 40 cm × 40 cm spacing. The results are in agreement with the findings of Hwu and Thseng (1982), who stated that spacing had no significant effect on 1000- grains weight. Weight of 1000- grains was not significantly affected by the interaction effect of number of seedlings hill^{-1} and spacing (Table 9). The highest 1000- grains weight (38.83 g) was obtained from $T_3 \times S_3$ treatment combination whereas the lowest 1000- grains weight (32.00 g) was obtained from $T_4 \times S_2$ treatment combination. The results are similar to the findings of Islam *et al.* (2012), who stated that interaction of hill density and number of seedlings hill^{-1} did not show any significant effect on 1000 grains weight.

Grain yield: Grain yield did not vary significantly due to number of seedlings hill^{-1} and spacing. Apparently the highest grain yield (2.25 t ha^{-1}) was obtained from six seedlings hill^{-1} while four seedlings hill^{-1} produced the lowest yield (1.84 t ha^{-1}) (Table 7). The results are similar to the findings of Mahamud *et al.*, (2013), who stated that grain yield was not significantly influenced by the number of seedlings hill^{-1}. The spacing of 30 cm × 30 cm visually produced the highest grain yield (2.56 t ha^{-1}) while 50 cm × 50 cm spacing produced the lowest grain yield (1.59 t ha^{-1}) (Table 8). The results are similar to the findings of Islam *et al.*, (2012), who observed that grain yield was not significantly affected by hill density. Grain yield was significantly affected by the interaction effect of number of seedlings hill^{-1} and spacing. The highest grain yield (3.19 t ha^{-1}) was produced by the treatment of $T_2 \times S_3$ while $T_3 \times S_1$ produced the lowest grain yield (1.39 t ha^{-1}) (Table 9). The results are similar to the findings of Bhowmik *et al.* (2012), who stated that the interaction of number of seedlings hill^{-1} and spacing was significant regarding grain yield.

Straw yield: The straw yield was not significantly affected by number of seedlings hill^{-1} and spacing. The highest straw yield (4.64 t ha^{-1}) was produced by 2 seedlings hill^{-1} and the lowest yield (4.38 t ha^{-1}) by 5 seedlings hill^{-1} (Table 7). Numerically the spacing of 30 cm × 30 cm produced the highest straw yield (5.44 t ha^{-1}) while 50 cm × 50 cm spacing produced

the lowest straw yield (3.51 t ha^{-1}) (Table 8). The results are similar to the findings of Islam *et al.* (2012), who observed that straw yield was not affected significantly by hill density but are in contradictory with the findings of Khalil (2001). Straw yield was significantly affected by the interaction effect of number of seedlings hill^{-1} and spacing. The highest straw yield (6.07 t ha^{-1}) was produced by the treatment combination of $T_1 \times S_3$ while the lowest (3.18 t ha^{-1}) was produced by $T_1 \times S_1$ (Table 9). The results are similar to the findings of Bhowmik *et al.* (2012), who stated that the interaction of number of seedlings hill^{-1} and spacing was significant regarding straw yield.

Biological yield: Number of seedlings hill^{-1}and spacing had no significant effect on biological yield. The highest biological yield (6.79 t ha^{-1}) was obtained from 2 seedlings hill^{-1} and the lowest biological yield (6.368 t ha^{-1}) was obtained from 4 seedlings hill^{-1} (Table 7). The results are similar to the findings of Mahamud *et al.* (2013), who stated that biological yield was not influenced by seedlings number hill^{-1}. The spacing of 30 cm × 30 cm produced the highest biological yield (7.99 t ha^{-1}) while 50 cm × 50 cm spacing produced the lowest straw yield (5.09 t ha^{-1}) (Table 8). The results are similar to the findings of Islam *et al.* (2012), who observed that biological yield was not affected significantly by hill density. Biological yield was influenced significantly by the interaction effect of number of seedlings hill^{-1} and spacing. The highest biological yield (8.54 t ha^{-1}) was produced by the treatment combination of $T_1 \times S_3$ and $T_1 \times S_1$ produced the lowest biological yield (4.75 t ha^{-1}) (Table 9). The results are similar to the findings of Bhowmik *et al.* (2012), who stated that the interaction of number of seedlings hill^{-1} and spacing was significant regarding biological yield.

Harvest index: Number of seedlings hill^{-1}and spacing did not show any significant effect on harvest index. Numerically higher harvest index (33.16%) was produced by 6 seedlings hill^{-1} and lower harvest index (29.77%) was produced by 4 seedlings hill^{-1} (Table 7). The results are similar to the findings of Shah *et al.* (1991) and Zhang and Huang (1990) who reported that harvest index was unaffected by the number of seedlings hill^{-1}. The spacing of 30 cm × 30 cm produced the highest harvest index (32.83%) while 50 cm × 50 cm spacing produced the lowest harvest index (31.29%) (Table 8). Harvest index was influenced significantly by the interaction effect of number of seedlings hill^{-1} and spacing. The highest harvest index (38.33%) was produced by the treatment of $T_2 \times S_3$ and $T_3 \times S_1$ produced the lowest harvest index (27.30%) (Table 9). The results are similar to the findings of Bhowmik *et al.* (2012), who stated that the interaction of number of seedlings hill^{-1} and spacing had significant effect on biological yield.

Conclusion

The results of the study indicate that individually number of seedling hill^{-1} and spacing had no significant effect on all the growth and yield contributing parameters but in case of interaction between the number of seedlings hill^{-1} and spacing had significant effect on plant height (except 90 DAT, 105 DAT and at harvest), number of tillers hill^{-1} (except 90 DAT, 105 DAT and at harvest), number of effective tillers hill^{-1}, grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, biological yield and harvest index. Separately number of seedlings and spacing had no significant effect on growth and yield parameters of rice. Numerically the highest value of almost all the growth and yield parameters were obtained

from 5 seedlings hill^{-1} (T_4) except panicle length, grain panicle^{-1} and 1000 grain weight. On the other hand highest value of all the growth and yield parameters were obtained from 30 cm x 30 cm (S_3) except panicle length and grain panicle^{-1}.But in the interaction effect 3 seedlings hill^{-1} with 30 cm x 30 cm spacing (T_2S_3) produced the highest grain yield and harvest index.

From the result of this study it can be concluded that the increase of seedlings hill^{-1} (6 seedlings) increased grain yield and harvest index, whereas in case of spacing, the closest spacing of 30 cm x 30 cm produced the highest yield. But among the interaction of seedling numbers hill^{-1} and spacing, 3 seedlings hill^{-1} with 30 cm x 30 cm spacing gave the highest grain yield and harvest index.

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