Published with Open Access at Journal BiNET
Vol. 04, Issue 01: 01-09
Journal of Bioscience and Agriculture Research
Home page: www.journalbinet.com/jbar-journal.html

Effects of Sowing Methods on Yield Attributes and Yield of Aus Rice under the Tidal Ecosystem

G. C. Das, S. C. Samanta, P. Biswas, N. K. Saha and J. Bhattacharya
Dept. of Agronomy, Patuakhali Science and Technology University (PSTU), Patuakhali, Bangladesh

ABSTRACT

An experiment was conducted at agronomy field laboratory of the Patuakhali Science and Technology University, Patuakhali to study the effect of sowing method and variety on the yield and yield components of Aus rice (direct-seeded pre-monsoon rice during March-June). Six varieties viz. BR2, BRRI dhan27, BRRI dhan48, Kaliboro, Kalihaita and Tepu and two sowing methods viz. broadcasting and line sowing were used under the tidal ecosystem. Factorial experiment was laid out in a split-plot design with three replications. Results revealed that line sowing gave the highest Leaf Area Index (LAI) (3.89), dry matter plant^{-1} (31.17 g), total number of tillers hill^{-1} (4.31), total number of spikelets panicle^{-1} (102.33), panicle length (21.60 cm), 1000-grain weight (25.33 g), grain yield (3.29 t ha^{-1}), straw yield (6.12 t ha^{-1}) and biological yield (9.41 t ha^{-1}) than the broadcasting method. Among the varieties the highest LAI (5.568), 1000-grain weight (29.73 g), grains panicle^{-1} (106), grain yield (3.71 t ha^{-1}) and harvest index (44.54%) were recorded from BRRI dhan48. The lowest LAI (2.17), effective tillers hill^{-1} (3.34), grains panicle^{-1} (51.17), total spikelets panicle^{-1} (62.67), grain yield (2.50 t ha^{-1}) and biological yield (7.28 t ha^{-1}) were recorded from Kalihaita. The interaction between sowing method and variety revealed that the highest, grain yield (3.82 t ha^{-1}) was recorded from BRRI dhan27 in line sowing. BRRI dhan48 in line sowing gave the highest LAI (5.66), harvest index (55.45%) and second highest grain yield (3.80 t ha^{-1}). On the other hand, Kalihaita in broadcasting gave the lowest LAI (2.157), grains panicle^{-1} (6.99), grain yield (2.37 t ha^{-1}) and biological yield (6.61 t ha^{-1}). Results suggested that BRRI dhan48 is suitable in line sowing for higher yield under tidal ecosystem of Patuakhali.

Keywords: *Aus rice, sowing methods, variety, yield and tidal ecosystem*

Please cite this article as: Das, G. C., Samanta, S. C., Biswas, P., Saha, N. K. & Bhattacharya, J. (2015). Effects of Sowing Methods on Yield Attributes and Yield of Aus Rice under the Tidal Ecosystem. *Journal of Bioscience and Agriculture Research* 04(01): 01-09.

I. Introduction

Rice is the staple food of Bangladesh which covers about 81% of total cropped area (BBS, 2010). Average yield of rice in Bangladesh is 4.28 tha^{-1} (Ricepedia, 2010), which is less than 30-50% of the world rice grain yield. Bangladesh has become self-sufficient in cereals. But population is

Corresponding author email: *goutam.pstu@gmail.com* (Das, G. C.)
eISSN: 2312-7945, © Das et al. 2015, Research paper

increasing rapidly. There is a need to increase rice yield in order to meet the demand of increasing population in the future. Adaption of improved management practices and high yielding variety are prerequisites to attain higher yield. *Aus* rice covers 1.05 million hectares of land with a production of 2.16 million tons rice (BBS, 2013). The Government of Bangladesh has given top priority for increasing the area and production of Aus rice to reduce the pressure on electricity for irrigation needed for Boro rice production during dry season.

Aus rice cultivation in the coastal area is predominantly practiced by transplanting method. Direct seeding is practiced in some areas of coastal belt. Direct seeding is increasingly being practiced by rice farmers in the world (Ismail *et al.* 2009). Ei-Sherief *et al.* (2004) reported that broadcasting was more efficient than other direct sowing methods and even better than transplanting, it gives highest average grain yield and yield components. The trend is the outcome of the scarcity of labour required for transplanting, simplicity and higher grain yield, reduced lodging, less drought risk and flooding damage and other additional benefits associated with direct seeding (Pendey *et al.* 1995).

Tidal wetland (non-saline) is one of the important areas of less favorable environments in Bangladesh covering a large area (1.9 m ha) of tidal floodplain land in the southern part of the country (Khan *et al.* 2004). The major environmental problem for crop production in tidal non-saline wetland situation in twice daily tidal inundation of land at over a period of 4-7 months (April-October) of the year. About 80% of the cultivable land of greater Barisal and Patuakhali is inundated up to a range of 6-90cm during this period (BRRI, 2004). Under tidal ecosystem of Bangladesh transplanted Aus rice is sometimes damaged due to tidal flooding. In 2013, Aus season a large area of *Aus* rice in coastal area was damaged due to cyclone *Mohasen* along with tidal flood. The literature survey reveals that direct seeded rice plants are more tolerant to submergence than transplanted rice plant. However, little information is available on sowing methods on different *Aus* rice varieties under tidal ecosystem. Hence the study was undertaken to determine the appropriate sowing method methods of different Aus rice varieties under tidal ecosystem of the coastal belt of Bangladesh.

II. Materials and Methods

The experiment was conducted at agronomy field laboratory of the Patuakhali Science and Technology University (PSTU), Dumki, Patuakhali during the period from April 2013 to August 2013. Two sowing methods viz. broadcasting & line sowing and six varieties viz. BR2, BRRI dhan27, BRRI dhan48, Kalihaita, Kaliboro & Tepu were selected for the experiment. The experiment was laid out in a split plot (sowing methods in the main plot and varieties in the sub-plot) design with three replications. The area of each plot was 10 m^2 (4.0 m × 2.5 m). The land was fertilized with Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) @ 150, 50, 75kg ha^{-1} respectively. The entire amount of TSP and MoP was applied as basal dose and incorporated into the soil at final land preparation. Urea was top-dressed in three equal splits, i.e., at 15 days after sowing, active tillering and panicle initiation stages (BARC, 2005). Seeds were sown on April 28, 2013 continuously in broadcasting and line as per treatment. Seed rate was 80 kg ha^{-1} in case of broadcasting and 50 kg ha^{-1} in case of line sowing. Line to line distance was 25 cm for line sowing method (BRRI, 2007). No weeds were grown due to tidal flood after sowing. Rouging was done at 30 days after sowing. Total experimental area was covered by net for controlling birds during panicle initiation to harvesting. The crop was harvested plot wise at full maturity on August 17, 2013. The yield contributing characters were recorded from 10 randomly selected hills $plot^{-1}$ outside the harvest area excluding border rows & plants and their mean values were determined. Yield data were collected from the central 5 m^2 area of each plot. Grain and straw yield was

Corresponding author email: *goutam.pstu@gmail.com* (Das, G. C.)
eISSN: 2312-7945, © Das et al. 2015, Research paper

recorded and converted to hectare (ha) basis. Data on plant height (cm), total number of tillers hill^{-1}, number of effective tillers hill^{-1}, number of non- effective tillers hill^{-1}, number of total spikelet panicle^{-1}, panicle length (cm), number of grains panicle^{-1}, number of sterile spikelet panicle^{-1}, weight of 1000-grains (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%).The collected data were analyzed using analysis of variance (ANOVA) and the mean differences were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

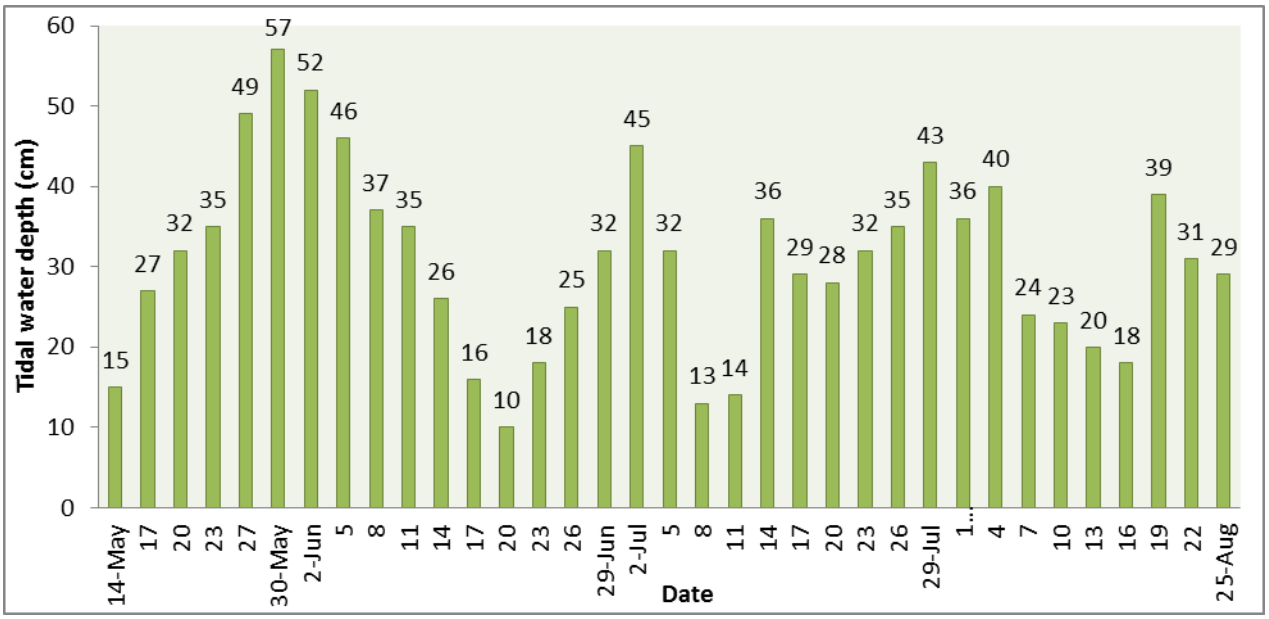

Figure. Tidal water depth at 3 days interval from 15 days after sowing to harvesting

III. Results and Discussion

Effects of sowing method

Sowing methods had significant effects on effective tillers hill^{-1}, total tillers hill^{-1}, grain yield, straw yield and biological yield. Line sowing method gave higher number of effective tillers hill^{-1}(4.02), grain yield (3.29 t ha^{-1}), straw yield (6.12 t ha^{-1}) and biological yield (9.41 t ha^{-1}) than the broadcasting method (Table 01). Mamun (2005) observed that line sowing method showed better performance than broadcast method. Bari (2004) also found significantly higher grain yield from direct wet seeded line sowing method than other methods. On the other hand sowing method did not significantly affect the plant height, leaf area index (LAI) at 50% flowering stage, dry matter plant^{-1} at 50% flowering stage, number of non-effective tillers hill^{-1}, grains panicle^{-1}, panicle length, 1000-grain weight and harvest index.

Effects of variety

Variety significantly influenced leaf area index (LAI) and dry matter plant^{-1} at 50% flowering stage, plant height, number of effective tillers hill^{-1}, non-effective tillers hill^{-1}, grains panicle^{-1}, sterile spikelets panicle^{-1}, 1000–grain weight, grain yield, straw yield, biological yield and harvest index. At 50% flowering stage, the highest leaf area index (5.57) was found in BRRI dhan48 and the lowest leaf area index (2.17) was found in Kalihaita (Table 01). Takeda *et al.*

Corresponding author email: *goutam.pstu@gmail.com* (Das, G. C.)
eISSN: 2312-7945, © Das et al. 2015, Research paper

(1983) observed that high-yielding rice varieties had higher LAI. Maximum dry matter plant^{-1} (38.87 g) was recorded from BR2 followed by BRRI dhan27 (34.69 g), BRRI dhan48 (28.19 g) and the minimum dry matter (25.92 g) was recorded in Kaliboro at 50% flowering stage. Gorgy (2010) reported that high-yielding rice varieties had significantly higher amount of dry matter plant^{-1} than local varieties. At harvest, the tallest plant height (155.0 cm) was recorded from Tepu and the shortest (110.3 cm) from BRRI dhan48 (Table 01). Munshi (2005) reported that modern varieties were shorter than local ones due to shorter internode length. BR2 and BRRI dhan48 gave the higher number of effective tillers hill^{-1} 4.73 & 4.40, respectively and lowest number of non-effective tillers hill^{-1}(0.10). Kalihaita (3.40) gave the minimum number of effective tillers hill^{-1} and maximum number of non-effective tillers hill^{-1} (0.0567). BR2 and BRRI dhan48 also gave the maximum (4.83) number of total tillers and the minimum (3.87) number of total tiller was recorded from BRRI dhan27 which was statistically similar with Tepu (3.93), Kalihaita (3.97) and Kaliboro (4.07). The lower tillers in the study might due to high tidal water depth during all growth stages. Rashid (2013) reported that due to high tidal water depth during tillering stage, lower number of tiller hill^{-1} might be produced. BRRI (1991) reported that the number of tillers hill^{-1} significantly differed from variety to variety. Anon. (1998) reported that high yielding variety had more bearing tillers m^{-2} over the inbred variety. Tepu gave the highest number of total spikelets panicle^{-1} (136.3) followed by BRRI dhan48 (116.3), BRRI dhan27 (112.2) and BR2 (104.8). On the other hand, Kalihaita gave the lowest number of grains panicle^{-1}(51.17) and total spikelets panicle^{-1} (62.67). BRRI (1994) reported that Tulshimala produced the highest number of spikelets panicle^{-1} than BR14. Uddin *et al.* (2011), Satyajit (2013) and Bakul *et al*. (2009) reported that differences in number of grains panicle^{-1} number of sterile spikelets panicle^{-1} were due to genotypic differences. Among the varieties BRRI dhan48 produced the highest 1000-grain weight (29.73 g), grain yield (3.71 t ha^{-1}), and harvest index (44.54%) (Table 01). On the other hand, Kalihaita produced the lowest grain yield (2.50 t ha^{-1}), biological yield (7.28 t ha^{-1}) and harvest index (34.40%). Ashrafuzzaman *et al*. (2009) observed similar findings, who reported that the variation in 1000–grain weight might be due to the varietal differences. Satytajit (2013) and Jeng *et al*. (2009) found the similar result in respect of 1000-grain weight. Hosain *et al.* (2014) reported that BRRI dhan48 produced the highest grain yield (3.51 t ha^{-1}) among different varieties. Similarly, Davaraju *et al.* (1998); Anon. (1998) and Leenakumari *et al.* (1993) also found higher grain yield from the hybrid varieties over the inbred varieties. Rahman (2001), Akbar (2004) and Uddin *et al*. (2011) reported that inbred variety produced higher biological yield, straw yield and harvest index than the hybrid varieties.

Interaction effects of sowing method and variety

The interaction between sowing method and variety was significant in case of dry matter plant $^{-1}$ at 50% flowering stage, plant height, number of effective tillers hill^{-1}, non-effective tillers hill^{-1}, total tiller panicle^{-1}, grains panicle^{-1}, sterile spikelets panicle^{-1}, total spikelets panicle^{-1}, 1000–grain weight, grain yield, straw yield, biological yield and harvest index. On the other hand in case of leaf area index (LAI) and panicle length, the interaction was not significant (Table 02).

The highest dry matter plant $^{-1}$ (39.06 g) was found in the line sowing method of BR2 which was statistically similar to broadcasting of BR2 (38.68 g) and the lowest (23.26 g) dry matter plant $^{-1}$ was found in broadcasting of Tepu which was also statistically similar with line sowing of Kalihaita (23.79 g) and broadcasting of Kaliboro (24.36 g). At harvest, line sowing of Tepu gave the tallest plant (156.8 cm). On the other hand shortest plant (109.3 cm) was recorded from the broadcasting of BRRI dhan48, which was statistically similar with line sowing of BRRI dhan48. Longxing *et al.* (2002) reported that plant height of the hybrid rice varied with planting method. BRRI dhan48 and BR2 sown in line sowing method produced maximum number of total tillers hill^{-1}(4.93) and effective tillers hill^{-1}(4.73). BR2 in broadcasting also gave the higher effective tillers hill^{-1}(4.73). The lowest number of total tillers hill^{-1}(3.67) was recorded from the interaction between broadcasting and BRRI dhan27. Kalihaita in broadcasting gave the lowest

Corresponding author email: *goutam.pstu@gmail.com* (Das, G. C.)
eISSN: 2312-7945, © Das et al. 2015, Research paper

number of effective tillers hill^{-1}(3.30) and the highest number of non-effective tillers hill^{-1} (0.67). BRRI dhan48 and BR2 in broadcasting produced no non-effective tillers hill^{-1}. Tepu produced the highest number of grains panicle^{-1}(110.3), sterile spikelets panicle^{-1} (31.67) and total spikelets panicle^{-1} (142.0) at harvest with broadcasting method. On the other hand Kalihaita in broadcasting method produced lower (49.67) number of grains panicle^{-1}, which was statistically similar with Kalihaita in line sowing (52.67). The lowest number of sterile spikelets panicle^{-1} (6.00) and total spikelets panicle^{-1} (58.67) was observed in line sowing with the variety Kalihaita, which was also statistically similar with broadcasting of Kaliboro. The highest 1000-grain weight (29.85 g) was recorded in broadcasting of BRRI dhan48, which was statistically similar with line sowing of BRRI dhan48 and line sowing of BRRI dhan27. The lowest 1000-grain weight was recorded in line sowing of BR2 (21.64 g) which was statistically similar with broadcasting of BR2 (21.85 g), line sowing of Tepu (21.98 g) and broadcasting of Tepu (22.69 g). The highest grain yield (3.82 t ha^{-1}) was found in the interaction of line sowing of BRRI dhan27, which was statistically similar with line sowing of BRRI dhan48 (3.80 t ha^{-1}). The lowest grain yield was recorded from the interaction between broadcasting and Kalihaita (2.37 t ha^{-1}), which was statistically identical with line sowing of Kalihaita and broadcasting of Kaliboro. Ang *et al.* (2002) also found significant variation in yield due to interaction of planting method and variety. The harvest index was the highest (55.45%) in line sowing of BRRI dhan48, which was statistically similar with broadcasting of BRRI dhan48 (55.41%). The lowest harvest index (31.79%) was recorded in line sowing of BRRI dhan27.

IV. Conclusion

Based on the results of the present study, it may be concluded that line sowing showed higher yield potential than broadcasting method. Though the highest yield was observed in BRRI dhan48, the yield of other varieties such as BRRI dhan27 and BR2 should be considered as it is important in socio-economic aspect of Aus rice productivity in the tidal ecosystem of Bangladesh. Further studies in different areas of the tidal ecosystem at relatively large scale are suggested to deliberately confirm, practice and extension of these study findings.

Corresponding author email: *goutam.pstu@gmail.com* (Das, G. C.)
eISSN: 2312-7945, © Das et al. 2015, Research paper

Table 01. Effects of sowing methods and varieties on the yield contributing characters and yield under the tidal ecosystem

Treatments	Plant height (cm)	LAI at 50% flowering stage	DM hill^{-1} at 50% flowering stage	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	No. of total tillers hill^{-1}	Grains panicle^{-1} (no.)	No. sterile spikelets panicle^{-1}	No. total spikelets panicle^{-1}	Panicle length (cm)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
Sowing method															
Broadcasting	135.283	3.826	29.817	3.84b	0.24	4.08a	79.89	21.00	100.89	21.23	25.42	3.02b	5.28b	8.30b	37.04
Line sowing	137.789	3.886	31.170	4.02a	0.29	4.31a	81.28	21.06	102.33	21.60	25.53	3.29a	6.12a	9.41a	35.73
$S\overline{x}$	0.1512	0.0110	0.4738	0.0208	0.0079	0.0208	1.2254	0.2390	1.3699	0.2297	0.0531	0.0264	0.0749	0.0901	0.3385
Level of significance	*ns*	*ns*	*ns*	*	*ns*	**	*ns*	*ns*	*ns*	*ns*	*ns*	**	**	**	*ns*
CV (%)	*1.53*	*1.69*	*4.09*	*5.41*	*11.18*	*4.87*	*5.67*	*7.66*	*5.07*	*5.83*	*2.34*	*6.62*	*4.08*	*3.49*	*5.29*
Variety															
BR2	122.4d	4.493c	38.872a	4.73a	0.10d	4.83a	77.67c	27.17b	104.8c	20.58a	21.74e	3.45b	4.88b	8.33b	41.41b
BRRI dhan27	143.8bc	5.083b	34.688b	3.67cd	0.20c	3.87c	89.33b	22.83c	112.2 b	21.72a	27.89b	3.45b	6.70a	10.15a	34.54d
BRRI dhan48	110.3e	5.568a	28.190c	4.40b	0.10d	4.50b	92.33b	24.00c	116.3 b	21.61a	29.73a	3.71a	4.62c	8.34b	44.54a
Kaliboro	142.3c	2.757e	25.917d	3.77c	0.30b	4.07c	66.17d	11.17d	77.33 d	21.43a	26.35c	2.80c	4.66c	7.46c	37.49c
Kalihaita	145.4 b	2.170f	27.132cd	3.40d	0.57a	3.97c	51.17e	11.50d	62.67 e	21.45a	24.82d	2.50d	4.79c	7.28c	34.40d
Tepu	155.0a	3.062d	28.160c	3.60cd	0.33b	3.93c	106.83a	29.50a	136.3 a	21.71a	22.34e	3.04c	4.54c	7.58c	40.38b
$S\overline{x}$	0.8511	0.02582	0.5088	0.08660	0.01291	0.08367	1.866	0.6575	2.105	0.5101	0.2439	0.08563	0.09487	0.1258	0.7855
Level of significance	**	**	**	**	**	**	**	**	**	*ns*	**	**	**	**	**
CV (%)	*1.53*	*1.69*	*4.09*	*5.41*	*11.18*	*4.87*	*5.67*	*7.66*	*5.07*	*5.83*	*2.34*	*6.62*	*4.08*	*3.49*	*5.29*

Corresponding author email: *goutam.pstu@gmail.com* (Das, G. C.)
eISSN: 2312-7945, © Das et al. 2015, Research paper

Table 02. Interaction effects of sowing methods and varieties on the yield contributing characters and yield under the tidal ecosystem

Methods	Varieties	Plant height (cm)	LAI at 50% flowering stage	DM hill^{-1} at 50% flowering stage	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	No. of total tillers hill^{-1}	Grains panicle^{-1} (no.)	No. sterile spikelets panicle^{-1}	No. total spikelets panicle^{-1}	Panicle length (cm)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
Broadcasting	**BR2**	120.7e	4.46d	38.68a	4.73a	0.00e	4.73a	80.67cd	27.67b	108.3cd	20.58a	21.85f	3.55abc	5.14b	8.69b	40.80b
	BRRI dhan27	142.5d	5.060c	35.16b	3.47cd	0.20d	3.67c	93.67b	21.67de	115.3 c	21.82a	28.23b	3.09de	5.20b	8.29bc	37.29c
	BRRI dhan48	109.3f	5.477b	26.95e	4.07b	0.00e	4.07b	78.67cd	21.00e	99.67 d	21.47a	29.85a	3.63ab	4.51c	8.14bc	55.41a
	Kaliboro	141.8d	2.737f	24.363f	3.73bc	0.40c	4.13b	66.33e	7.00g	73.33 ef	20.89a	26.06d	2.63fg	4.70c	7.33e	35.89c
	Kalihaita	144.2cd	2.157g	30.377c	3.30d	0.67a	3.97bc	49.67f	17.00f	66.67 fg	21.27a	23.87e	2.37g	4.24de	6.61f	35.82c
	Tepu	153.2b	3.060e	23.260f	3.73bc	0.20d	3.93bc	110.33a	31.67a	142.0 a	21.38a	22.69f	2.87ef	3.88e	6.75f	42.54b
Line sowing	**BR2**	124.1e	4.52d	39.06a	4.73a	0.20d	4.93a	74.67d	26.67bc	101.3 d	20.58a	21.64f	3.34bcd	4.63cd	7.97cd	42.03b
	BRRI dhan27	145.0cd	5.107c	34.21b	3.87bc	0.20d	4.07b	85.00c	24.00cd	109.0cd	21.62a	27.54bc	3.82a	8.20a	12.01a	31.79d
	BRRI dhan48	111.4f	5.660a	29.43cd	4.73a	0.20d	4.93a	106.00a	27.00b	133.0 b	21.76a	29.60a	3.80a	4.73c	8.53bc	55.45a
	Kaliboro	142.8cd	2.777f	27.47de	3.80bc	0.20d	4.00bc	66.00e	15.33f	81.33 e	21.98a	26.63cd	2.97def	4.63cd	7.60de	39.08bc
	Kalihaita	146.6c	2.183g	23.787f	3.50cd	0.47b	3.97bc	52.67f	6.00g	58.67 g	21.62a	25.77d	2.62fg	5.33b	7.95cd	32.98d
	Tepu	156.8a	3.063e	33.06b	3.47cd	0.47b	3.93bc	103.33a	27.33b	130.7 b	22.05a	21.98f	3.21cde	5.20b	8.41bc	38.22c
$S_{\bar{x}}$		1.204	0.0365	0.7195	0.1225	0.0183	0.1183	2.639	0.9299	2.976	0.721	0.3450	0.1211	0.1342	0.1780	1.111
Level of significance		**	*ns*	**	**	**	**	**	**	**	*ns*	**	*	**	**	**
CV (%)		*1.53*	*1.69*	*4.09*	*5.41*	*11.18*	*4.87*	*5.67*	*7.66*	*5.07*	*5.83*	*2.34*	*6.62*	*4.08*	*3.49*	*5.29*

Corresponding author email: *goutam.pstu@gmail.com* (Das, G. C.)
eISSN: 2312-7945, © Das et al. 2015, Research paper

V. References

[1] Akbar, M. K. (2004). Response of hybrid and inbred rice varieties to different seedlings ages under system of rice intensification in transplant aman season. M.S. (Ag.) Thesis. Dept. Agron., BAU, Mymensingh.

[2] Ang, S., Wang, X., Xiong, Z. and Xie, S. (2002). Assessment of using SRI with the super hybrid rice variety Liangyoupei 9. In: Assessments of the System of Rice Intensification. Proc. Intl. Conf., Sanya, China. Apr. 1-4. pp. 112-113.

[3] Anonymous, (1998). Technical report on hybrid rice Aalok 6201. Dept. Soil Sci., BAU, Mymensingh. pp. 1-7.

[4] Ashrafuzzaman, M., Islam, M. R., Ismail, M. R., Shahidullah, S. M., and Hanafi, M. M. (2009). Evaluation of six aromatic rice varieties for yield and yield contributing characters. *Int. J. Agric. Biol.*, 11: 616–620.

[5] Bakul, M. R. A., M. S. Akter, M. N. Islam, M. M. A. A. Chowdhury and M. H. A. Amin. (2009). Water stress effect on morphological characters and yield attributes in some mutants T–Aman rice lines. *Bangladesh Res. Pub. J.*, 3(2): 934–944.

[6] Bangladesh Bureau of Statistics (BBS), (2008-2010). Statistical Year Book of Bangladesh, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

[7] BARC (Bangladesh Agriculture Research Counci), (2005). Fertilizer Recommended Guide (BARC, 2005), Bangladesh Agriculture Research Council, Farm gate, Dhaka, Bangladesh.

[8] Bari, S. M. W. (2004). Effect of method of planting and weeding on the yield and yield contributing characters of Aman rice cv. BRRIdhan 32. M.S. (Ag.) Thesis. Dept. Agron., BAU, Mymensingh.

[9] BBS (Bangladesh Bureau of Statistics), (2013). Yearbook of Agricultural Statistics of Bangladesh. Ministry of Planning. Govt. of the People's Republic of Bangladesh, Dhaka. pp 136–140.

[10] BRRI (Bangladesh Rice Research Institute), (1994). Annual Report for 1991. Bangladesh Rice Res. Inst. Joydebpur, Gazipur, Bangladesh. BRRI Pub No. 108 pp.57-66.

[11] BRRI (Bangladesh Rice Research Institute) (1991). Annual Report for 1988. Bangladesh Rice Res. Inst. Joydebpur, Gazipur, Bangladesh. pp. 10-23.

[12] BRRI (Bangladesh Rice Research Institute). (2004). Varieties surviving under stress conditions. In: Proceeding of the Workshop on Modern Rice cultivation in Bangladesh, 29-31 January 2002, Bangladesh Rice Research Institute, Joydebpur, Gazipur- 1701, Bangladesh. pp. 224.

[13] BRRI (Bangladesh Rice Research Institute), (2007). Adhunik Dhaner Chash (in Bengali). Bangladesh Rice Research Institute, Joydebpur, Gazipur, pp: 36.

[14] Davaraju, K. M., Gowda, H. and Raju, B. M. (1998). Nitrogen response of Karnatoka Rice Hybrid 2. *Intl. Rice Res. Notes.* 23(2): 43.

[15] El-Sherif, E. I., El-Heaty, M., Galel, A. A. and Abd El-Hameed, A. (2004). Effect of nitrogen levels, hill spacing's and rice cultivars mixtures on some rice characters. *J. Agric. Sci. Mansoura Univ.* 29(2): 535-552.

[16] Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research. 2nd ed. John Wiley and Sons. New York. pp: 64.

[17] Gorgy, R. N. (2010). Effects of different land preparation treatments and planting methods on growth, yield and yield components of three rice cultivars. J. *Agric. Res. Kafer EI-sheikh Univ.* pp. 36.

[18] Hosain M. T., Ahamed K. U., Haque M. M., Islam M. M., Fazle Bari A. S. M., Mahmud, J. A. (2014). Performance of hybrid rice (*Oryza sativa* L.) varieties at different transplanting dates in Aus season. *App. Sci. Report.* 1 (1):1-4.

[19] Ismail A. M., Ella, E. S., Vergara, G.V. and Machil, D. J. (2009). Mechanism associated with tolerance to flooding during germinating and early seedling growth in rice (*Oryza sativa* L.). *Ann. Botany.* 103(2):197-209.

Corresponding author email: *goutam.pstu@gmail.com* (Das, G. C.)
eISSN: 2312-7945, © Das et al. 2015, Research paper

[20] Jeng, T. L., Tseng, T. H., Wang, C. S., Chen, C. L. and Sung, J. M. (2009). Yield and grain uniformity in contrasting rice genotypes suitable for different growth environments. *Field Crops Res.*, 99: 59–66.
[21] Khan, M. A. H., Hossain, M. A., Quddus, M. A., Alam, M. M. and Elahi, N. E. (2004). Potential rice based cropping system for different ecosystems. In. Proceding of the Workshop on Modern Rice cultivation in Bangladesh, 29-31 January 2002, Bangladesh Rice Research Institute, Joydebpur, Gazipur- 1701, Bangladesh. pp. 102.
[22] Leenakumari, S., Maltadevappa, M., Vidyachandra, B. and Krishnamurthy, R. A. (1993). Performance of experimental rice hybrids in Bangalore, Kamatoka, India. *Intl. Rice Res. Notes.,* 18(1): 16.
[23] Longxing, T., Xi, W. and Shaokai, M. (2002). Physiological effects of SRI methods on the rice plant. China National Rice Res. Inst., Hangzhou. [http://ciifad. cornell.edu/sri/proc1/sri_29.pdf].
[24] Mamun, M. A. (2005). Influence of planting technique on growth and yield of aman rice. M.S. in Agron. Thesis, Sher-e-Bangla Agricultural University, Dhaka.
[25] Munshi, R. U. (2005). A comparative morph physiological study between two local and two modern rice cultivars. M.S. Thesis, Dept. Crop Bot., Bangladesh Agric.Univ.Mymensingh. pp. 20-29.
[26] Pandey, S., Velasco, L., Masicat, P. and Gagalac, F. (1995). An economic analysis of need establishment methods in Pangasinan ,Central Luzon Paper by Social Sciences Division L S Banos, (Philippines) International Rice Research Institution. pp. 32.
[27] Rahman, M. M. (2001). Effect of seedling age and spacing on the productivity of hybrid rice Sonarbangla-1. M.S. Thesis, Dept. Agron., BAU, Mymensingh.
[28] Rashid, F. M. H. (2013). Effect of Seedling Raised In Different Land Types on The Yield And Yield Attributes of Traditional T. Aman Rice Varieties Under Tidal Ecosystem. M.S. Thesis, Dept. Agron., PSTU, Patuakhali.
[29] Ricepedia.org, (2010). CGIAR Ricepedia-the online authority on rice. [Retrieved 13 April 2015 from http://ricepedia.org/bangladesh]
[30] Satyajit, R. (2013). Effect of seedling number hill^{-1} on the yield of modern varieties of T. Aman rice under tidal non-saline ecosystem. M.S. Thesis, Dept. Agron., PSTU, Patukhali.
[31] Takeda, T., Oka, M. and Agata, W. (1983). Characteristics of dry matter and grains production of rice cultivars in warmer part of Japan. I. Comparison of dry matter production between old and new types of rice*. Japanese J. Crop Sci.* 52(3): 299-306.
[32] Uddin, M. J., Ahmed, S., Harun–or–Rashid, M., Hasan, M.A. and Asaduzzaman, M. (2011). Effect of spacing on the yield and yield attributes of transplanted Aman rice cultivars in medium lowland ecosystem of Bangladesh. *J. Agric. Res.*, 49(4): 465–476.
[33] Uddin, M. J., Hasan, M. M., Ahmed, S. and Hasan, M. M. (2010). Effect of spacing on morpho–physilogical response of different t. Aman rice cultivars under coastal high land ecosystem. *Indian J. Agric. Res.*, 44(4): 251–258.

Corresponding author email: *goutam.pstu@gmail.com* (Das, G. C.)
eISSN: 2312-7945, © Das et al. 2015, Research paper