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Performance of GSR genotype as influenced by different crop establishment methods

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Abstract

Different crop establishment methods are used in Asian rice cultivation system. Though transplanting is the most popular method, farmers also tend to direct seeding to reduce production cost. A field trial was conducted to evaluate the performance of newly selected Green Super Rice (GSR) genotype under dry direct line seeding, wet direct line seeding and conventional tillage puddle transplanting methods at BRAC Agricultural Research and Development Centre (BARDC), Gazipur during *Boro* 2012-13 and *Aman* 2013. . Performance of HHZ-15-DT7-SAL4-SAL1 was evaluated in both the seasons. Two BRRI released varieties BRRI dhan28 and BRRI dhan39 were used as check in *Boro* and *Aman,* respectively. Experiment was conducted following split-plot design with three replications accommodating genotypes (G_1= HHZ-15-DT7-SAL4-SAL1, G_2= In case of *Boro* BRRI dhan28 and in *Aman* BRRI dhan39) in sub plot and different establishment methods (M_1= Dry direct line seeded method, M_2= Wet direct line seeded method, M_3=conventional tillage puddle transplanting method) in main plot. Establishment methods had significant effects on yield and yield attributes. Growth duration significantly varied in both the seasons. In *Boro*, maturity duration for GSR genotype and check variety was similar but 25 days shorter in *Aman season*In *Boro*, HHZ-15-DT7-SAL4-SAL1 gave higher yield as wet direct line seeded rice . Also this genotype showed statistically similar yield in both wet direct line seeded (4.92 tha^{-1}) and conventional tillage puddle transplanting (4.91 tha^{-1}) method in *Aman* 2013. In both the seasons, HHZ-15-DT7-SAL4-SAL1 produced the highest yield regardless of all establishment methods.

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Introduction

Rice (*Oryza sativa*) is the staple food for more than half of the population of the world. Demand for rice is growing upward worldwide due to population increase and urbanization (Mishra, 2009). About 75% of total cropped area and more than 80% of the total irrigated area is planted to rice in Bangladesh (Hossain and Deb, 2003). Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh (Hossain, 2002). Thus, rice plays a very important role in the livelihood of the people. To meet up the world's food demand by 2025, it is estimated that rice production has to increase globally by 60% (Fageria, 2007). But the productivity and sustainability of rice-based cropping systems are threatened because of increasing scarcity of water and labor, inefficient use of fertilizer, climate change, the emerging energy crisis and rising fuel prices and emerging socioeconomic changes such as urbanization, migration of labor, preference of nonagricultural work (Ladha *et al*., 2009). To address these issues, technological innovations and agronomic management are needed. Major contributing factors for increased rice production are introduction of modern varieties, expansion of irrigated area during *Boro* season and improved agricultural practices, increasing use of fertilizer, herbicide, and pesticide (Karim *et al*. 2014).

At present, rice cultivation is done in different ways in the world. The most important cultivation ways are direct seeding and transplanting methods. In recent years, Many Asian farmers are shifting rice establishment method from transplanting in to direct seeding in either puddle or dry soil after dry tillage because the latter requires less labour, time, drudgery and cultivation cost (Bhushan *et al*., 2007; Pandey and Velasco, 2002; Yamauchi *et al*., 2000). Direct seeding requires only 34% of the total labour requirement of transplanted rice (Ho Nai-Kin and Romli, 2002) and 29% of the total cost of transplanted rice production without any yield loss (Akkas *et al.,* 2012). Farmers usually practice direct seeding of rice by broadcast method.

This method of rice establishment substantially reduces labour requirement, improves emergence of seeds, and reduces lodging to less than 10% (Bakker *et al*., 2002). Wet direct seeding on puddle soil either through broadcasting or in lines is gaining popularity due to lower labor requirement, shorter crop period and efficient water use (Pandey and Velasco, 2002). It differs with respect to varietal choice, seed rate, water and fertilizer management. Direct seeding of rice is the water and labor- saving technique of cultivation (Mahajan *et al*., 2006). It eliminates the need of seedling rising, maintaining and subsequent directly seeded crops are faster and easier to plant, less labor intensive and consume less water (Jehangir *et al*., 2006).

However, direct seeding has some disadvantages also. Weed problem is severe in direct seeded field. Also sometimes uneven emergence of rice seedlings is observed (Rajkumara *et al*., 2003). Precision leveling and water management in land should be done, which sometimes cannot be done accurately. Though direct seeded rice has some problem, it received much attention all over the world by the agronomist because of its low-input demand. With suitable cultivars, land leveling, water and weed management it is possible to adapt direct seeded rice profitably. Therefore, the present study was designed to evaluate the effect of rice establishment methods on the yield and yield attributes of GSR genotypes.

Material and methods

Location and experimental design

The experiment was conducted at BRAC Agricultural Research and Development Centre, Gazipur during *Boro* 2012-13 and *Aman* 2013. Experiment was conducted following split-plot design withthree replication. Unit plot size was 14.88 m^2.

Plant material

The performance of selected GSR genotype, HHZ-15-DT7-SAL4-SAL1 was grown as dry and wet direct line seeding and compared with conventional tillage method. BRRI dhan28 and BRRI dhan39 were used as check varieties in *Boro* and *Aman* season, respectively.

Agronomic management

In dry direct line seeding, dry tillage was done using power tiller at shallow depth (15cm) and row to row distance was 20 cm. In this system, dry seeds were used for seeding. In wet direct line seeding, land preparation was done like conventional puddle system and pre germinated seeds were used for line seeding at 20 cm row spacing. In both dry and wet direct line seeding, 60 kg ha^{-1} seed was sown. In conventional tillage puddle transplanted rice, 40 kg ha^{-1} seed was used for seedling raising. Twenty-nine and 20 days old seedlings for *Boro* and *Aman* were used, respectively. Urea, TSP, MoP, Gypsum and $ZnSO_4$ fertilizer were applied at 220-130-120-70-10 kg ha^{-1} for *Boro* and @ 180-80-70-60-10 kg ha^{-1} for *Aman*. The whole amount of TSP, MoP, Gypsum, ZnSO4 and one third of Urea was applied as basal application. The remaining urea was applied in two equal splits (73 kg ha-1 for Boro and 60 kg ha-1 for Aman) at maximum tillering stage and just before panicle initiation stage. All agronomic practices were performed uniformly for all the treatments. Weeding was done two to three times and insecticides were applied as and when necessary to keep the fields free from insect-pests. All other recommended cultural management practices were followed to ensure good crop stand.

Data collection

Three hills (excluding border hills) from each plot were selected and tagged after transplanting for taking yield and yield components data at harvest. Morphological data were collected for eight quantitative characters at the appropriate growth stage of rice plants following the description for *Oryza sativa* L. (IRRI, 2002). Harvesting was done depending upon the maturity of varieties. The harvesting area was $6m^{-2}$. Harvested crop of each plot was separately bundled, properly tagged and then brought to the threshing floor and threshed by pedal thresher. Then the crop was dried, cleaned and necessary data such as 1000 grain weight (g), grains $panicle^{-1}$ (no.) and plot yield (kg) were collected. The weight of grains was adjusted to 14% moisture content.

Statistical analysis

The collected data were compiled and tabulated for statistical analysis. Data were analyzed following the analysis of variation (ANOVA) technique and means were adjusted by Least Signisicant Different test (LSD) using the statistical computer package program, MSTAT-C (Russell, 1986).

Results and discussion

Results showed that among all the studied traits 50% flowering, 1000 grain weight (g), yield (tha^{-1}) for both season and growth duration, effective tillers m^{-2} (no.), panicle m^{-2} (no.) for Aman had significant influence due to genotypes. Also most of the yield components except plant height for *Boro* and panicle m^{-2} (no.) for *Aman* had significant influence due to different establishment methods.

Table 1. Mean performance of days to 50% flowering. The mean performance was tested by LSD.

Establishment methods	Genotypes		
	G_1	G_2	
Season 1 (*Boro* 2012-13)			
M_1	122 a	112 b	117 A
M_2	112 b	123 a	118 A
M_3	102 c	91 d	97 B
	112 *A*	109 *B*	
Season 2 (*Aman* 2013)			
M_1	72 d	81 bc	77 B
M_2	71 e	81 b	76 B
M_3	80 c	83 a	82 A
	74 *B*	82 *A*	

Capital letter (A…) shown variation between establishment methods

Italic capital letter *(A…)* shown variation between genotypes

Small letter (a…) shown comparison with establishment methods and genotypes.

Days to 50% flowering

Analysis of variance showed that different establishment methods (M), Genotypes (G) and their interaction (M X G) had significant effect on days to 50% flowering in *Boro* 2012-13 (Table 9). Among the tested genotypes, the highest mean performance (112 days) for this trait was found in G_1 and the lowest (109 days) from G_2 (Table 1). So, G_1 and G_2 having shorter growth duration than other tested genotypes. However, in case of establishment methods the highest mean was observed in M_1 (117 days) and M_2 (118 days) respectively but the lowest in M_3 (97 days). Therefore, conventional tillage puddle transplanting method (M_3) may be shorten days to 50% flowering. The longest duration (123 days) was found in the combination of M_2 X G_2 as well as the shortest (91 days) from M_3 X G_2 combination.

Table 2. Mean performance of plant height (cm). The mean performance was tested by LSD.

Establishment methods	Genotypes		
	G_1	G_2	
Season 1 (*Boro* 2012-13)			
M_1	108 ab	113 a	111
M_2	107 b	107 ab	107
M_3	108 ab	111 ab	110
	108	110	
Season 2 (*Aman* 2013)			
M_1	120	122	121
M_2	120	122	121
M_3	120	123	121
	120	122	

Small letter (a...) shown comparison with establishment methods and genotypes

Table 3. Mean performance of growth duration (days). The mean performance was tested by LSD.

Establishment methods	Genotypes		
	G_1	G_2	
Season 1 (*Boro* 2012-13)			
M_1	150 a	142 c	146 A
M_2	147 b	142 c	145 B
M_3	126 d	141 c	134 C
	141	142	
Season 2 (*Aman* 2013)			
M_1	96 e	121 b	109 B
M_2	91 f	119 c	105 C
M_3	104 d	127 a	116 A
	97 *B*	122 *A*	

Capital letter (A...) shown variation between establishment methods

Italic capital letter *(A...)* shown variation between genotypes

Small letter (a...) shown comparison with establishment methods and genotypes.

In *Aman* 2013, Analysis of variance showed that different establishment methods (M), Genotypes (G) and their interaction (M X G) had significant effect on days to 50% flowering (Table 9). Among the tested genotypes, the highest mean performance (82 days) was found in G_3 and the lowest (109 days) from G_2 (Table 1). So, G_1 and G_2 having shorter growth duration than other tested genotypes. However, in case of establishment methods the highest mean was observed in M_1 (117 days) and M_2 (118 days) respectively but the lowest in M_3 (97 days). Therefore, conventional tillage puddle transplanting method (M_3) may be shorten days to 50% flowering.

The longest duration (123 days) was found in the combination of M_2 X G_2 as well as the shortest (91 days) from M_3 X G_2 combination.

Plant height

Analysis of variance showed that, different establishment methods (M), Genotypes (G) and their interaction (M X G) had no significant effect on plant height in both seasons (Table 9).

Numerically in *Boro*, among the tested genotypes, the higher plant height was showed by G_2 (110cm) and lower in G_1 (108cm). However in case of establishment methods, highest plant height was found in M_1 (111cm) and lowest in M_2 (107cm) (Table 2). In *Aman*, all establishment methods showed same plant height (121cm). On the other hand, G_2 showed maximum (122cm) and G_1 showed minimum (120cm) plant height.

Table 4. Mean performance of effective tillers m^{-2} (no.). The mean performance was tested by LSD.

Establishment methods	Genotypes		
	G_1	G_2	
Season 1 (*Boro* 2012-13)			
M_1	449	480	464
M_2	609	489	549
M_3	433	447	440
	500	472	
Season 2 (*Aman* 2013)			
M_1	429 a	337 b	383 AB
M_2	415 a	399 a	407 A
M_3	399 a	301 b	350 B
	414 *A*	346 *B*	

Capital letter (A…) shown variation between establishment methods

Italic capital letter *(A…)* shown variation between genotypes

Small letter (a…) shown comparison with establishment methods and genotypes.

Growth duration

Analysis of variance showed that, different establishment methods (M), Genotypes (G) and their interaction (M X G) had significant effect on growth duration in *Boro* season (Table 9). Among the tested genotypes higher mean performance was showed by G_2 (142days) (Table 3).

In case of establishment methods, M_1 showed highest growth duration (146days) followed by M_2 (145days) and M_3 (134days). The longest growth duration (150 days) was found in the combination of M_1 X G_1 as well as the shortest (126days) from M_3 X G_1 combination.

Table 5. Mean performance of panicle m^{-2} (no.). The mean performance was tested by LSD.

Establishment methods	Genotypes		
	G_1	G_2	
Season 1 (*Boro* 2012-13)			
M_1	424	441	432
M_2	572	461	516
M_3	419	428	423
	471	443	
Season 2 (*Aman* 2013)			
M_1	407 a	301 b	354
M_2	375 ab	361 ab	368
M_3	368 ab	291 b	330
	383 *A*	318 *B*	

Italic capital letter *(A…)* shown variation between genotypes

Small letter (a…) shown comparison with establishment methods and genotypes.

In *Aman*, analysis of variance showed significant effect in case of establishment methods (M) and genotypes (G). Interaction (M X G) had no significant effect on growth duration (Table 9). Among the tested genotypes higher mean performance was showed by G_3 (122days) and lower was in G_1 (97days) (Table 3).

In case of establishment methods, M_3 showed highest growth duration (116days) followed by M_1 (109days) and M_2 (105days). The longest growth duration (127 days) was found in the combination of M_3 X G_3 as well as the shortest (91days) from M_2 X G_1 combination.

Table 6. Mean performance of grains panicle^{-1}(no.). The mean performance was tested by LSD.

Establishment methods	Genotypes		
	G_1	G_2	
Season 1 (*Boro* 2012-13)			
M_1	136 abc	121 bc	129 B
M_2	100 c	106 c	103 B
M_3	163 a	156 ab	160 A
	133	128	
Season 2 (*Aman* 2013)			
M_1	102 c	98 c	100 B
M_2	102 c	100 c	101 B
M_3	129 a	121 b	125 A
	111	106	

Capital letter (A...) shown variation between establishment methods

Small letter (a...) shown comparison with establishment methods and genotypes.

Effective tillers m^{-2}

Analysis of variance showed that, different establishment methods (M), Genotypes (G) and their interaction (M X G) had no significant effect in *Boro*, but in *Aman* establishment methods and genotypes showed significant variation in effective tillers m^{-2} (Table 9). In *Boro*, among the tested genotypes, G_1 showed higher no. of effective tillers m^{-2} (500) and G_2 gave lower (472) (Table 4).

On the other hand, among the establishment methods, M_2 gave highest (549) and M_3 gave lowest (440) effective tillers m^{-2}. In *Aman*, G_1 showed higher no. of effective tillers m^{-2} (414) and G_2 gave lower (346). On the other hand, among the establishment methods, M_2 gave highest and M_3 gave lowest effective tillers m^{-2}.

Table 7. Mean performance of 1000 grain weight(g). The mean performance was tested by LSD.

Establishment methods	Genotypes		
	G_1	G_2	
Season 1 (*Boro* 2012-13)			
M_1	22 ab	21.1 abc	21.6 A
M_2	22.2 a	20.4 c	21.3 A
M_3	21.5 abc	20.5 bc	21 B
	22*A*	21 *B*	
Season 2 (*Aman* 2013)			
M_1	21.4 ab	21.9 ab	22 A
M_2	22.6 a	19.8 c	21 B
M_3	20.6 bc	22.4 bc	22 A
	22 *A*	21 *B*	

Capital letter (A...) shown variation between establishment methods

Italic capital letter *(A...)* shown variation between genotypes

Small letter (a...) shown comparison with establishment methods and genotypes.

Among the combinations, M_1 X G_1, M_2 X G_3, M_3 X G_3 and M_2 X G_3 gave statistically higher and similar result followed by the combination of M_1 X G_3 and M_3 X G_3.

Number of panicle m⁻²

In this factor, analysis of variance showed that, different establishment methods (M), Genotypes (G) and their interaction (M X G) had no significant effect in *Boro*, but in *Aman* establishment methods and genotypes showed significant variation (Table 9). In *Boro*, among the tested genotypes, G_1 showed higher no. of panicle m^{-2} (471) and G_2 gave lower (443) (Table 5). On the other hand, highest mean performance among the establishment methods was showed by M_2 (516) followed by M_1 (432) and M_3 (423). In *Aman*, G_1 showed higher no. of panicle m^{-2} (383) and G_3 gave lower (318) (Table 5). On the other hand, highest mean performance among the establishment methods was showed by M_2 (368) followed by M_1 (354) and M_3 (330). Among the combinations, M_1 X G_1 highest (407) and M_3 X G_3 gave lowest panicle m^{-2} (291).

Table 8. Mean performance of yield (tha^{-1}). The mean performance was tested by LSD.

Establishment methods	Genotypes		
	G_1	G_2	
Season 1 (*Boro* 2012-13)			
M_1	7.38 b	5.46 d	6.42 B
M_2	8.16 a	6.02 cd	7.09 A
M_3	7.36 b	6.71 bc	7.04 A
	7.63 *A*	6.06 *B*	
Season 2 (*Aman* 2013)			
M_1	4.58 a	3.83 b	4.21 B
M_2	4.92 a	3.41 b	4.17 B
M_3	4.91 a	4.76 a	4.84 A
	4.80 *A*	4.00 *B*	

Capital letter (A…) shown variation between establishment methods

Italic capital letter *(A…)* shown variation between genotypes

Small letter (a…) shown comparison with establishment methods and genotypes.

Grains panicle⁻¹

In case of grains panicle⁻¹ analysis of variance showed that, different establishment methods (M), Genotypes (G) and their interaction (M X G) had no significant effect in *Boro*, but in *Aman* only genotypes showed significant variation (Table 9). In *Boro*, highest mean performance was showed by G_1 (133) and lowest by G_2 (128) (Table 6). Statistically higher performance showed on M_3 (160) followed by M_1 (129) and M_2 (103). Among the interactions, M_3 X G_1 performed best (163). In *Aman*, numerically highest mean performance was showed by G_1 (111) followed by G_3 (106) (Table 6). In case of establishment methods, M_3 showed higher no. of grains panicle⁻¹ (125) and M_1 (100) and M_2 (101) showed lower and statistically similar result. Among the combinations, M_3 X G_1 gave highest (129) and M_3 X G_3 gave lowest (98) grains panicle⁻¹.

Thousand grain weight

Apparently, in *Boro*, higher 1000 grain weight (22g) was found in G_1 than G_2 (21g). In case of establishment methods, M_1(21.6g) and M_2 (21.3g) gave statistically similar and higher 1000 grain weight followed by M_3 (21g). Among the combinations, M_2 X G_1 gave highest (22.2g) and M_2 X G_2 gave lowest (20.4g) 1000-grain weight (Table 7). Analysis of variance showed significant variation in genotypes (G) and interaction (M X G) but establishment methods did not show significant effect (Table 9).

Table 9. Analysis of variance of all the characters with level of significance.

Item	F Value							
	50F	PH	DM	TN	PN	GP	TGW	Yield
Season 1(Boro 2012-13)								
Establishment methods (M)	87.67s	3.75n	697.75s	2.50n	2.1n	13.37n	14.45n	5.76n
Genotypes (G)	25.71s	3.3n	81.0s	0.33n	0.46n	0.46n	11.63s	87.92s
Interaction (M X G)	113.74s	0.58n	9.0s	1.18n	1.02n	0.49n	0.68s	7.68s
Season 2 (Aman 2013)								
Establishment methods (M)	256.75s	0.10n	33.73s	8.77s	50.09s	0.49n	1.80n	7.13s
Genotypes (G)	1984.5s	0.92n	34.57s	32.09s	6.21s	7.60s	0.19n	14.00s
Interaction (M X G)	226.5s	0.02n	0.07n	4.73n	1.11n	1.32n	14.40s	2.05n

n= Non significant, where $p>0.05$ and s = Significant, where $p<0.05$

Indicators: 50F= Days to 50% flowering, PH= Plant height (cm), DM= Days to maturity, TN= Effective tillers m^{-2} (no.), PN= Number of panicle m^{-2}, GP= Grains $panicle^{-1}$ (no.), TGW= Thousand Grain Weight (g).

In case of *Aman*, analysis of variance showed that, only interaction (M X G) showed significant effect. Establishment methods (M) and Genotypes (G) did not show significant variation (Table 9). In between two genotypes, G_1 (22g) performed better than G_3 (21g) and in case of establishment methods, M_1 (22g) and M_3 (22g) showed highest and statistically similar 1000-grain weight followed by M_2 (21g). Among combinations, M_2 X G_1 gave highest (22.6g) and M_2 X G_3 gave lowest (19.8g) result (Table 7).

Grain yield

Analysis of variance showed that, genotypes (G) and interaction (M X G) showed significant effect but establishment method (M) had no significant effect on grain yield in *Boro* season (Table 9). Between genotypes, G_1 performed better (7.63 tha^{-1}) than G_2 (6.06 tha^{-1}) and in case of methods, M_2 (7.09 tha^{-1}) and M_3 (7.04 tha^{-1}) performed statistically similar and higher yield than M_1 (6.42 tha^{-1}). Among combinations, highest value was found in M_2 X G_1 (8.16 tha^{-1}) and lowest was found in M_1 X G_2 (5.46 tha^{-1}) (Table 8).

In *Aman*, analysis of variance showed significant effect on establishment methods (M) and genotypes (G). Interaction (M X G) had no significant effect on grain yield. Between tested genotypes, numerically higher mean performance was showed by G_1 (4.80 tha^{-1}) and G_2 showed lower performance (4.00 tha^{-1}). In case of methods, M_3 performed best (4.84 tha^{-1}) followed by M_1 (4.21 tha^{-1}) and M_2 (4.17 tha^{-1}).

Among combinations, highest value (4.92 tha^{-1}) for grain yield was found in M_2 X G_1 and lowest (3.41 tha^{-1}) was found in M_2 X G_3 combination (Table 8).

Correlation analysis

Correlation coefficient analysis measures the linear relationships between characters and determines the selection of component characters for plant improvement (Singh, 2000). In this study (Table 10), correlation analysis revealed that, days to 50% flowering found to display insignificant negative correlation with grain yield.

However, days to 50% flowering positive significant correlation with days to maturity, but significant negative correlation with tillers m^{-2} and grains $panicle^{-1}$ which indicated that genotypes which took more days to flowering have the longer growth duration and late flowering genotypes furnished with less number of tillers m^{-2} and grains $panicle^{-1}$. Iftekharuddaula *et al.* (2001) found similar findings that satisfied the present findings. Day to flowering also showed positive insignificant correlation with plant height and panicles m^{-2} and negative insignificant correlation with thousand grain weight.

Plant height had non-significant negative correlation with grain yield, tillers m^{-2}, panicle m^{-2} and grains panicle^{-1} which indicated that increased of plant height decreased the value of grain yield, tillers m^{-2}, panicle m^{-2} and grains panicle^{-1}. Plant height showed positive correlation with days to 50% flowering and Days to maturity indicating longer duration genotypes had taller plant height.

Days to maturity represented insignificant positive correlation with grain yield. However, days to maturity have positive significant correlation with days to 50% flowering, number of panicles m^{-2} but significant negative correlation with grains panicle^{-1} which indicated that genotypes which took more days to flowering have the longer growth duration (Table 10). We can also say, late maturing genotypes furnished more number of panicles per hill associated with less number of tillers m^{-2} and grains panicle^{-1}. Iftekharuddaula *et al.* (2001) found similar findings that satisfied the present findings.

Table 10. Correlation co-efficient among the agronomic traits using genotypes means.

	50F	PH	DM	TN	PN	GP	TGW
PH	0.303 ^{ns}						
DM	0.814***	0.396 ^{ns}					
TN	-0.669**	-0.237 ^{ns}	-0.725***				
PN	0.406 ^{ns}	-0.001 ^{ns}	0.684***	-0.226 ^{ns}			
GP	-0.589**	-0.268 ^{ns}	-0.632**	0.929***	-0.082 ^{ns}		
TGW	-0.274 ^{ns}	0.230 ^{ns}	0.055 ^{ns}	-0.316 ^{ns}	-0.073 ^{ns}	-0.292 ^{ns}	
Yield	-0.116 ^{ns}	-0.202 ^{ns}	0.305 ^{ns}	-0.010 ^{ns}	0.662***	0.138 ^{ns}	0.300 ^{ns}

***indicate significant at 0.1%, ** indicate significant at 1% level of probability, * indicate significant at 5% level of probability, ns: not significant.

Indicators: 50F= Days to 50% flowering, PH= Plant height (cm), DM= Days to maturity, TN= Effective tillers m^{-2} (no.), PN= Number of panicle m^{-2}, GP= Grains panicle^{-1} (no.), TGW= Thousand Grain Weight (g).

Effective tillers m^{-2} showed negative insignificant correlation with grain yield and positive significant correlation with grain panicle^{-1} (no.) (Table 10). Also it showed negative insignificant correlation with Panicle m^{-2} (no.) and 1000 grain weight (g). Negative significant correlation was also found with effective tillers m^{-2}.

Number of panicle m^{-2} represented significant positive correlation with grain yield and number of days to maturity. This result indicates, longer maturity period and production of a good number of panicle m^{-2} by appropriate management practice can improve yield. This trait had positive insignificant association with days to 50% flowering but negative insignificant correlation with Grains panicle^{-1} (no.), 1000-Grain Weight (g), plant height and effective tillers m^{-2} .

Grains panicle^{-1} showed positive insignificant correlation with grain yield and highly positive significant association with effective tillers m^{-2}. Negative significant correlation was observed in days to 50% flowering and days to maturity with Grains panicle^{-1}. This indicates Grains panicle^{-1} can be increased by increasing effective tillers m^{-2}. Negative correlation with 1000 grain weight (g) was also found (Table 5). Biswas *et al.* (2000) reported negative association between number of grains panicle^{-1} and 1000 grain weight which confirmed present findings.

The relationship of 1000-grain weight (g) and yield was positive and insignificant. This can indicate that, yield can improve by increasing 1000-grain weight. Also plant height and days to maturity had positive insignificant correlation with 1000-grain weight.

Weed management

Under direct seeding, weeds are the biggest biological constraint. Weeds such as grasses, sedges, and broadleaf weeds were found in dry direct line seeded (M_1) and wet direct line seeded (M_2) plot. . The dominant weeds in M_1 and M_2 fields were *Echinochloa crusgalli* and *Leptochloa chinensis* among grasses, *Cyperus difformis* and *Fimbristylis miliacea* among sedges, and *Ammania baccifera, Eclipta prostrata,* and *Sphenoclea zeylanica* in the broadleaf category. It was commonly observed that, M_1 was subjected to relatively more weed pressure than M_2, probably because of differences in land preparation. Manual and mechanical methods were used to manage weeds in direct-seeded rice.

Pest and disease management

Compared with M_3, the outbreak of insect pests and diseases was more severe in M_1 and M_2 because of high plant density and the consequent cooler, more humid, and shadier microenvironment inside the canopy. The major insect pests of M_1 and M_2 were BPH, stem borer, green leafhopper, leaf folder, and gall midge. In case of disease, Bacterial leaf blight affected M_2. Other insect pests that attack emerging rice seedlings are the snail (*Pomacea canaliculata* [Lamarck]) and rats. Protecting young seedlings against these pests was more difficult in M_1 and M_2 than in M_3.

Research need

Crop growth and yields of direct-seeded rice can be further improved by using specifically bred rice varieties resistant to insects and improving certain crop management practices. Additional research is needed in crop lodging, water management, nutrient management, weed ecology and management and management of high planting or tiller density.

Conclusion

Direct seeding could be an attractive alternative to transplanting of rice. It is expected to minimize labor input and reduce cultivation cost. Location-specific synergistic combinations of technology options have to be identified and used to maximize economic returns to farmers and environmental benefits to the community.

Regarding grain yield production in both season, HHZ 15-DT7-SAL4-SAL1 produced better yield than BRRI dhan28 and BRRI dhan39 regardless of all establishment methods. However, this genotype yielded maximum under wet direct line seeding method due to higher number of panicle production per unit area and 1000-grain weight and it almost 10% higher than dry direct line seeding and conventional tillage puddle transplanting method.

References

Bakker RR, Bell MA, Rickman JF. 2002. Mechanization issues in tillage and crop establishment for dry direct-seeded rice. In: Direct seeding: research issues and opportunities. Proceedings of the International Workshop on Direct Seeding in Asian Rice Systems: Strategic Issues and Opportunities, Bangkok, Thailand. Los Banos, Philippines, 25-28 January 2000,: International Rice Research Institute, 219-230.

Bhushan L, Ladha JK, Gupta RK, Singh S, Tirol-Padre A, Saharawat YS, Gathala M, Pathak H. 2007. Saving of water and labor in rice-wheat system with no tillage and direct-seeding technologies. Agronomy Journal **99(5),** 1288-1296.

Biswas PS, Prasad B, Dewan SBA. 2000. Variability, character association and path analysis in rice (*Oryza sativa* L.). Bangladesh Journal of Plant Breeding and Genetics **13(1),** 19-25.

Fageria NK. 2007. Yield physiology of rice. Journal of Plant Nutrition **30,** 843-879. http://dx.doi.org/10.1080/15226510701374831

Mahajan G, Sardana V, Brar AS, Gill MS. 2006. Effect of Seed Rate, Irrigation Intervals and Weed Pressure on Productivity of Direct Seeded Rice (*Oryza sativa* L.)," Indian Journal of Agricultural Science, **76(12),** 756-759.

Hossain M, Deb UK. 2003. Liberalization of rice sector: Can Bangladesh withstand regional competition? Poster paper presented at PETRRA communication fair 2003 held at hotel Sheraton, Dhaka on Aug. 10-11.

Hossain MZ. 2002. Performance of BRRI dhan32 in the SRI and conventional methods and their technology mixes. MS thesis, Dept. of Agronomy, BAU, Mymensingh, 28-71.

Nai-Kin H, Romli Z. 2002. Impact of direct seeding on rice cultivation: lessons from the Muda area of Malaysia. In: Direct seeding: research issues and opportunities. Proceedings of the International Workshop on Direct Seeding in Asian Rice Systems: Strategic Issues and Opportunities, Bangkok, Thailand. Los Baños, Philippines, 25-28 January 2000,: International Rice Research Institute, 87-98.

Hobbs PR, Singh Y, Giri GS, Lauren JG, Duxbury JM. 2002. Direct seeding and reduced tillage options in the rice-wheat systems of the Indo-Gangetic plains of South Asia. In: Direct seeding: research issues and opportunities. Proceedings of the International Workshop on Direct Seeding in Asian Rice Systems: Strategic Issues and Opportunities, Bangkok, Thailand. Los Baños, Philippines, 25-28 January 2000,: International Rice Research Institute, 201-215.

IRRI. 2002. Standard Evaluation System for Rice. International Rice Research Institute, Los Banos, Philippines.

IRRI. 2008. Rice Production Training Module: Method of Planting Rice. International Rice Research Institute, Los Banos, Philippines, 1-13.

Iftekharuddaula KM, Badshah MA, Hassan MS, Bashar MK, Akter K. 2001. Genetic variability, character association and path analysis of yield components in irrigated rice (*Oryza sativa* L.). Bangladesh Journal of Plant Breeding and Genetics **14(2),** 43-49.

Ladha JK, Kumar V, Alam MM, Sharma S, Gathala MK, Chandna P, Saharawat YP, Balasubramanian V. 2009. Integrating crop and resource management technologies for enhanced productivity, profitability and sustainability of the rice-wheat system in South Asia, 29-30.

Mishra A. 2009. System of rice intensification (SRI): A quest for interactive science to mitigate the climate change vulnerability. Asian Institute of Technology, Agricultural systems and Engineering; School of environment, Bankok, Thailand. IOP Conf. Series: Earth Environmental Science **6(24),** 20-28.

Karim MR, Alam MM, Ladha JK, Islam MS, Islam MR. 2014. Effect of different irrigation and tillage methods on yield and resource use efficiency of Boro rice (Oryza sativa). Bangladesh Journal of Agricultural Research **39(1),** 151-163.

Ali MA, Ladha JK, Rickman J, Lales JS, Alam MM. 2012. Evaluation of drill seeding patterns and nitrogen management strategies for wet and dry land rice. Bangladesh Journal of Agricultural Research **37(4),** 559-571.

Rashid MH, Parvin N, Dewan MR, Ali MH. 2014. Productivity of dry seeded and transplanted rice (oryza sativa) in *Aman* season. Bangladesh Journal of Agricultural Research **39(1),** 185-187.

Rana MM, Mamun MAA, Zahan A, Ahmed MN, Mridha MAJ. 2014. Effect of planting methods on the yield and yield attributes of short duration aman rice. American Journal of Plant Science **5,** 251-255.
http://dx.doi.org/10.4236/ajps.2014.53033

Pandey S, Velasco L. 2002. Economics of direct seeding in Asia: patterns of adaption and research priorities. In: Direct seeding: research issues and opportunities. Proceedings of the International Workshop on Direct Seeding in Asian Rice Systems: Strategic Issues and Opportunities, Bangkok, Thailand. Los Banos, Philippines, 25-28 January 2000,: International Rice Research Institute, 3-14.

Rajkumara S, Hanamaratti NG, Prashanthi SK. 2003. Direct wet seeding in rice – a review. Agricultural Reviews **24(1),** 57-63.

Gupta RK, Naresh RK, Hobbs PR, Jiaguo Z, Ladha JK. 2003. Sustainability of Post-Green Revolution Agriculture. The rice-Wheat Cropping Systems of the Indo-Gangetic plains and China, In: Improving the Productivity and Sustainability of Rice-Wheat Systems: Issues and Impacts, ASA Special Publication 65, Washington DC, 1-26.

Russell DF. 1986. MSTAT-C Package Programme. Crop and Soil Science Department, Michigan State University, USA.

Subbaiah SV, Krishnaiah K, Balasubramanian V. 2002. Evaluation of drum seeder in puddle rice, Agricultural Mechanization in Asia, Africa and Latin America, 33, 23-26.

Singh RK, Singh US, Khush GS, Rashmi R. 2000. Genetics and biotechnology of quality traits in aromatic rices. In Aromatic Rices. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd., 47-71.

Balasubramanian V, Hill JE. 2002. Direct seeding of rice in Asia: Emerging issues and strategic research needs for the 21st century. In: Pandey S, Mortimer M, Wade L, Tuong TP, Lopez L, Hardy B (eds.). Direct Seeding: Research Strategies and Opportunities. International Rice Research Institute. 15-39.

Jehangir WA, Masih I, Ahmed S, Gill MA, Ahmad M, Mann RA, Chaudhary MR, Turral H. 2005. Sustaining Crop Water Productivity in Rice-Wheat Systems of South Asia: A Case Study from Punjab Pakistan. International Water Management Institute, Lahore, Pakistan.

Yamauchi M, Aragones DV, Casayuran PR, Asis CA, Cruz RT. 2000. Seedling establishment and grain yield of tropical rice sown in puddle soil. Agronomy Journal **92(2),** 275-282.