Rice Research: Open Access
ISSN: 2375-4338

Johora et al., J Rice Res 2015, 3:3
DOI: 10.4172/2375-4338.1000146

Research Article Open Access

Optimizing Sowing Methods Through Estimates of Interactions between Sowing Date and Genotypes in Some Morpho-Physiological Traits in Rice (*Oryza sativa L*)

Fatema-Tuj-Johora[1]*, Jalal Uddin Ahmed[2], Morshed[3] M, Mian MAK[4] and Ariful Islam M[5]

[1]*Department of Crop Botany, EXIM Bank Agricultural University, Bangladesh*

[2]*Dept of Crop Botany, BSMRAU, Gazipur1706, Bangladesh*

[3]*Senior Scientist, IRRI, Philippines*

[4]*Department of Genetics and Plant Breeding, BSMRAU, Gazipur1706, Bangladesh*

[5]*Department of GPB, EXIM Bank Agricultural University, Bangladesh*

Abstract

For optimizing some morpho-physiological traits in two different sowing methods of boro rice genotypes at varying seeding time, a field experiment was carried out by IRRI at the research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur; Bangladesh during 2010-12. A decreasing trend of plant height was observed at sowing dates after 8th December and the decreasing trend continued until January 07. The smaller plant in delayed seeding indicate the sensitivity of late seeding low temperature on the dry matter production of the genotype, unlike other genotypes which expressed no significant reduction in plant height due to late seeding. Significant responses of environments were found either in between the varieties but in between the sowing dates. Maximum number of effective tillers was observed in both direct seeded and transplanted condition in December 18. The tiller number increased with delayed seeding until December 18. But tillers numbers were found to decline afterwards. PSBRC82 took maximum days to flowering sowing at December 08th in transplanting condition but first flowering in direct seeding condition which is statistically different. And the earliest flowering was observed in BRRI dhan28 sowing at January 07. In direct seeding condition than in transplanting.OM2718 gave the maximum sterility when it was practiced in transplanting method than the direct seeded method at January 07. The increase of filled grains reflects clearly that the number of filled grains exhibited higher in direct seeded methods than transplanting method in all genotypes interaction with sowing date of December18th. Such difference in number of filled grains might be due to undisturbed root establishment in direct seeding method than transplanted Method. PSBRC82 sowing at December 18 resulted the highest grain yield in direct seeding methods followed by in BRRI dhan28 in transplanting.

Keywords: Optimizing; Direct seeding; Transplanting; Sowing dates; Genotypes; Effective tillers and harvest index

Introduction

Rice (*Oryza sativa* L.) is the world's second most important food crop after wheat. It is the most extensively cultivated crop and viewed as staple food in Bangladesh. More than 90% of the people depend on rice for their diets. Among the major rice growing countries of the world, Bangladesh ranks third in rice cultivated area and fourth in production. Before 1970, 95% of the total rice in the world was being produced by the method of direct seeding. The modernization in rice cultivation started with the advent of IRRI (International Rice Research Institute). Afterword's, transplanting was found to be the most popular method of rice cultivation. But in the extreme conditions due to meet up the need to feed the hunger we had to go through direct seeding method. The transplanting method requires a large amount of labor. In addition, under the changing socioeconomic environment, workers are not available or reluctant to undertake operations like nursery transplanting. These situations further escalate labor costs. Alternate methods of establishing crops, especially rice, that require less labor and water without sacrificing productivity are needed. Direct-seeded rice can achieve equivalent yields to transplanted rice across a range of rice cultivars in common use. Although no statistical significant differences in yield so a higher cost: benefit ratio for direct-seeded rice (1.59) than for transplanted rice (0.96). Net labor savings with direct-seeded rice compared with transplanting averaged 27 days/ha [4]. Direct seeding methods encompasses a set of principles, each of them fairly simple, but working synergistically with the others in order to achieve higher grain yield. In Bangladesh, direct seeded rice produced about 2-12% higher grain yield than transplanting. These situations further escalate labor costs. In boro season poor seedling growth is a main problem in transplanting method compared to direct seeding. Transplanting of aged seedlings caused considerable reduction in yield and yield components, since grain yield and its components depended mainly on seedling age at the time of transplanting beside the other factors controlling growth and yield [1-7].

Objective:

To evaluate the morpho-physiological traits of rice in direct seeding method as compared to transplanting method.

***Corresponding author:** Fatema-Tuj-Johora, Lecturer, Department of Crop Botany, EXIM Bank Agricultural University, Bangladesh, Tel: +88-01833414348; E-mail: fatemamoona@ymail.com

Received May 05, 2015; **Accepted** August 26, 2015; **Published** September 01, 2015

Citation: Johora FT, Ahmed JU, Morshed M, MAK M, Islam MA (2015) Optimizing Sowing Methods Through Estimates of Interactions between Sowing Date and Genotypes in Some Morpho-Physiological Traits in Rice (*Oryza sativa L*). J Rice Res 3: 146. doi:10.4172/2375-4338.1000146

Materials and Methods

The experiment was carried out at the research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur under the department of Crop Botany during Boro (Winter) seasons from November 2009 to May 2010. The experimental site is located at the centre of Madhupur Tract at 24°09/ North latitude and 90°26/ East longitude with elevation of 8.4 meter from sea level. The Soil of the experimental site was clay loam of shallow red brown in texture belonging to Salna series. The seeds were collected from genetic resources center (GRC) of International Rice Research Institute (IRRI) and Bangladesh Rice Research Institute (BRRI). Different sowing dates were, Sowing date 01, December 08/2009: Sowing date 02, December 18/2009: Sowing date 03, December 28/2009 and Sowing date 04, January 07/2010. Seeds were sowed directly for direct seeding and soaked separately for 48 hr in clothes bag for the method of transplanting. Soaked seeds were picked out from water and wrapped with straw and gunny bag to increase the temperature for facilitating germination. Fertilizers were applied according to manual of BRRI; N @ 110 kg/ha, P_2O_5 90 kg/ha, K_2O 75 kg/ha, and Gypsum 60 kg/ha. Total Nitrogen was applied in four installments at just before seeding, at 15 DAT (Days after transplanting), 30 DAT and 45 DAT recommended by BRRI. Other fertilizers were applied during the final land preparation. Land was well plowed, well puddled and leveled for the seedbed. About 250 g seeds were soaked for 24 hr in transplanting methods. Soaked seeds were kept under straw for 3 days. Sprouted seeds of each variety were sown. The channels (15 cm deep and 50 cm wide) were used for irrigation and drainage. A foliar spray of Furadan 5 G was applied to protect the seedlings against insect pests. Healthy seedlings of 40 days old were transplanted on each plot of the experimental field. In each plot for transplanting 20cm × 20cm (line to line and seedling to seedlings) spacing and for direct seeded condition 3-4 seeds were sown per pit as a distance of 20 cm from line to line and 15 cm from plant to plant as recommended. In direct seeded condition 3-4 seeds were sown per pit as a distance of 20 cm from line to line and 15 cm from plant to plant as recommended. A bundle of seedlings were kept at the side of each plot for gap filling and gap filling was done at seven days of transplanting to replace the dead ones. Hand weeding was done to keep the experimental field free from weed infestation throughout the crop growth phases. The field was irrigated properly and 5-10 cm water depth was maintained up to heading in transplanted method. A good drainage system was also maintained specially after flowering. The excess water was drained out leaving the soil only at saturated condition. Data were collected on seedling mortality, days to panicle initiation, total number of effective tillers per panicle and biological yield. Three factor Split-split plot design where the used methods of sowing (main plot), sowing dates (sub plot) and genotypes were in sub-sub plot. The whole experimental area was divided into different blocks and sub-blocks and sub-sub-blocks, representing three replications. Four rice varieties were assigned randomly to each unit plot of 5.8 m × 2.6 m dimension. All the collected data of the present study were statistically analyzed using MSTAT-C Program. The statistical analysis for various characters under investigation were done and the analysis of variance for each of the characters was performed by F test and mean values were separated by lsd.

Genotypes used

Four different genotypes were used in the study .The seeds were collected from genetic resources center (GRC) of the International Rice Research Institute (IRRI) and Bangladesh Rice Research Institute (BRRI) (Table 1).

Sl no.	Germplasms Identity	Source of planting materials
1	OM 2718	International Rice Research Institute (IRRI)
2	PSBR 82	International Rice Research Institute (IRRI)
3	BRRI dhan28	Bangladesh Rice Research Institute (BRRI)
4	BRRI dhan36	Bangladesh Rice Research Institute (BRRI)

Table 1: Source of planting materials and their identity.

Result and Discussion

Plant height (cm)

Varietal mean represents PSBRC-82 as the tallest (122.71 cm) among the genotypes whereas the dwarfing natures of BRRI dhan36 (106.20 cm). Statistically significant differences were recorded from genotypes to genotypes but neither for sowing dates not sowing methods. In combined interaction it is clearly observed that the tallest plant was found in PSBRC82 sowing on 8 December in direct seeding methods and the smallest plant was found in BRRI dhan36 sowed on 7thJanuary 2010 in transplanted condition. A decreasing trend of plant height was observed on sowing dates after 8th. December and the decreasing trend continued until 7th January. The smaller plant in delayed seeding indicate the sensitivity of late seeding low temperature on the dry matter production of the genotype unlike other genotypes which expressed no significant reduction in plant height due to late seeding. In transplanting method comparative low plant height was observed which might be due to low soil temperature than the direct sowing condition. In direct seeded condition the field was dry whereas in transplanting condition an adequate amount of moisture was maintained within the field (Table 2).

Number of effective tillers per hill

In respect of direct seeded boro rice, the highest number of effective tillers per hill was found in PSBRC to be 82 sowing at December 18 (20.247) and the lowest number of effective tillers per hill was found in OM 2718 sowing in January 07 (5.40).In transplanted boro rice, the highest number of effective tiller was found in PSBRC 82 sowing at December 18 (19.60). And the lowest number of effective tiller per plant (5.73) was found in OM 2718 sowing at January 07. The results indicated that direct seeded boro rice is superior over transplanted rice in respect of effective tiller per hill. However significant responses for environments were found either in between the varieties but not in between the sowing dates. Maximum number of effective tillers was observed in both direct seeded and transplanted condition executed on December 18. The tiller number increased with delayed seeding until 18 December but tillers numbers were found to decline afterwards. Although transplanting is the common rice growing practice in Bangladesh but for obtaining maximum effective tillers on December 18 in PSBRC 82 direct seeded method might be practiced (Table 3).

Days to first flowering

In combined interaction PSBRC 82 took maximum days to flowering (124.667 days) sowing on December 08 in transplanting condition but first flowering in direct seeding condition which is statistically different (116.826 days). The earliest flowering (90.39 days) was observed in BRRI dhan28 sowing at 7 January in direct seeding condition than (93.335 days) in transplanting. It is clear that in both the cases direct seeding is earlier than transplanting. Similar results were observed in respect of panicle initiation, so it might be concluded that panicle initiation is positively correlated with days to first flowering i.e., the earlier the panicle initiation the earlier the flowering. It indicated that a genotype may give better yield whether it is earlier or late. Days

Genotypes	Plant height (cm)								Mean
	Direct seeding				Transplanting				
	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	
BRRI Dhan 28	117.732	115.095	111.992	108.541	113.021	110.482	107.514	104.202	111.07
BRRI Dhan 36	112.571	110.044	107.073	103.784	108.073	105.643	102.797	99.635	106.20
PSBRC-82	130.063	127.153	123.736	119.922	124.862	122.064	118.785	115.136	122.71
OM-2718	125.035	122.237	118.946	115.283	120.034	117.341	114.185	110.676	117.96
Mean	121.355	118.636	115.436	111.883	116.497	113.883	110.813	107.409	11.67
SE	1.998	1.954	1.902	1.844	1.918	1.876	1.826	1.771	
Lsd	7.53								
CV %	12.843								

SE = Standard Error
Lsd = Least significant difference (Genotype × Methods of Sowing × Date of sowing)
CV % = Co-efficient of variation

Table 2: Plant height (cm) of four different genotypes in four different sowing dates in both direct seeding and transplanting conditions.

Genotypes	Number of effective tillers per hill								Mean
	Direct seeding				Transplanting				
	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	
BRRI Dhan 28	14.759	18.357	12.936	10.427	14.112	17.630	12.299	9.790	13.289
BRRI Dhan 36	11.348	14.465	6.850	8.702	10.711	13.818	9.153	8.065	10.389
PSBRC-82	15.582	20.247	17.542	11.358	14.935	19.600	13.955	10.711	15.491
OM-2718	8.379	10.006	9.575	5.400	9.692	14.259	8.928	5.733	8.996
Mean	12.517	14.769	11.726	8.972	12.363	16.327	11.084	8.575	12.041
SE	1.656	2.101	2.304	1.312	1.276	1.384	1.228	1.095	
Lsd	2.62								
CV %	7.993								

SE = Standard Error

Lsd = Least significant difference (Genotype × Methods of Sowing × Date of sowing)

CV % = Co-efficient of variation

Table 3: Number of effective tillers per hill of four different genotypes at different sowing dates in both direct seeding & transplanting conditions.

to flowering were reduced in case of direct seeding than transplanting methods in all genotypes. This can be used to interpret that in the transplanting method seedling establishment, duration might cause much variation (Table 4).

Days to maturity

Among the genotypes, PSBRC 82 took the highest days for maturation followed by for OM 2718 whereas the lowest days for maturation was shown by BRRI dhan28.In respect of sowing dates, sowing on 8th December took the highest days for maturation whereas the lowest number of dates taken for maturation was in sowing on January 7th.In direct seeded boro rice the highest days to maturity was taken by PSBRC 82 sowing at 8th December while the lowest days to maturity was observed in BRRI dhan28 sowing on the 7th.of January. In combined interaction the interaction highest days for maturation (157.04 days) was observed in PSBRC 82 sowing at December8 in transplanting and 153.63 days in direct seeding condition. The earliest flowering (124.53) was observed in BRRI dhan28 sowing on 7 January in direct seeding condition than 130.32 in transplanting. It is clear that in both the cases direct seeding the flowering is earlier than transplanting. Similar results were observed with respect of panicle initiation, with regard to days to first flowering and days to 100% flowering (Table 5).

Spikelet's sterility percent

The inverse relationship existing between spikelet's sterility percent and yield was observed. Variety, OM 2718 gave the maximum sterility (43.550) when it was practiced in transplanting method than the direct seeded method (40.701) on January 07th. From the temperature graph it was clearly observed that during the 1st week of January it was below 10 °C what is very detrimental. During the germination to seedling stage the severe cold injury affects the number of tillers per plant as well as spikelet's fertility. Whereas favorable temperature in 1st and 2nd week of December decrease spikelet's sterility as well as increased effective tillers per plant. Infact the Lsd values signifies that there is no statistical differences in BRRI dhan28 although germinated from 8th December to 7th January either in direct seeding or transplanting. Physiological homeostasis (maintenance of relative stable condition in varying environments) is much higher in BRRI dhan28 than the other three varieties. Thus, BRRI dhan28 has the ability to adopt to a varying range of temperatures. Although higher fertility (low sterility percent) was found in BRRI dhan36 but its low effective tillers per plant invaueds its suitability. Among the genotypes the maximum fluctuation in spikelet's sterility percent was found in OM 2718 (25.026-43.550 %) whereas the minimum fluctuation in BRRI dhan28 (20.942-29.321 %). From this table it might be concluded that OM 2718 has the higher sensitivity while BRRI dhan28 has the minimum sensitivity (Table 6).

Filled grains (number) per panicle

An important observation with respect to filled grains per plant indicated that in all the interactions between genotypes and sowing dates, direct seeded condition exhibited superior performances than transplanted condition. Higher filled grains per plant is a major criteria of increasing grain yield i.e., conversion of photosynthates (source) to sink. The highest number of filled grains per plant (196.323) was found in PSBRC 82 sowed on 18th.December, by direct seeding methods while statistically, similar result (192.432) was also found in transplanting

Genotypes	Days to first flowering								Mean
	Direct seeding				Transplanting				
	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	
BRRI Dhan 28	109.966	101.685	94.531	90.395	112.906	104.625	97.471	93.335	100.614
BRRI Dhan 36	111.926	103.645	96.491	92.355	119.766	111.485	104.331	100.195	105.024
PSBRC-82	116.826	108.545	101.391	97.255	124.666	116.385	109.231	105.095	112.924
OM-2718	114.866	106.585	99.431	95.295	122.706	114.425	107.271	103.135	107.964
Mean	113.396	105.115	97.961	93.825	120.011	111.730	104.576	100.440	105.882
SE	1.523	1.543	1.052	1.623	2.453	2.098	2.008	2.097	
Lsd	5.356								
CV %	4.821								

SE = Standard Error
Lsd = Least significant difference (Genotype × Methods of Sowing × Date of sowing)
CV %= Co-efficient of variation

Table 4: Days to first flowering of four different genotypes at different sowing dates interaction with both direct seeding & transplanting methods.

Genotypes	Days to maturity								Mean
	Direct seeding				Transplanting				
	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	
BRRI Dhan 28	140.34	131.67	127.74	124.53	148.44	139.61	132.56	130.32	134.15
BRRI Dhan 36	143.05	138.33	134.38	127.23	145.27	141.46	137.34	136.11	140.40
PSBRC-82	153.63	148.96	144.02	138.85	157.04	153.21	148.18	142.88	148.97
OM-2718	146.96	139.27	134.33	128.18	149.24	147.37	143.35	138.08	141.85
Mean	146.99	139.56	134.62	129.70	151.25	144.91	140.36	136.35	141.334
SE	1.960	1.838	1.928	1.625	1.276	1.562	1.764	1.154	
Lsd	5.35								
CV %	4.071								

SE = Standard Error
Lsd = Least significant difference (Genotype × Methods of Sowing × Date of sowing)
CV % = Co-efficient of variation

Table 5: Days to maturity of four different genotypes at different sowing date's interaction with both direct seeding & transplanting method.

Genotypes	Spikelet's sterility percent								Mean
	Direct seeding				Transplanting				
	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	
BRRI Dhan 28	22.184	20.942	27.218	27.403	23.737	22.408	29.123	29.321	25.292
BRRI Dhan 36	17.926	11.921	21.767	21.301	19.180	12.756	23.290	22.792	18.867
PSBRC-82	27.645	20.079	30.962	29.682	29.580	21.485	33.130	31.760	28.040
OM-2718	27.015	25.026	36.394	40.701	28.906	26.778	38.942	43.550	33.414
Mean	23.692	19.492	29.085	29.772	25.351	20.857	31.121	31.856	26.403
SE	1.960	1.838	1.928	1.625	1.276	1.562	1.764	1.154	
Lsd	5.35								
CV %	4.071								

SE = Standard Error
Lsd = Least significant difference (Genotype × Methods of Sowing × Date of sowing)
CV % = Co-efficient of variation

Table 6: Spikelet's sterility percent of four different genotypes at different sowing date's interaction with both direct seeding & transplanting method.

methods. Number of filled grain was increased up to a level(state the level) (December 18) and after attaining this critical level it decreased up to last sowing dates (January 07). The highest filled grains might be due to higher number of effective tillers per panicle, lower spikelet sterility (higher spikelet fertility), low seedling mortality and favorable atmospheric and adaphic temperature during that particular time. Although a moderate number of filled grains per plant (146.793) was found in BRRI dhan28 but very minimum spikelet sterility percent indicated that most grains were converted to filled grains. Therefore the increase of filled grains reflects clearly that the number of filled grains exhibited is higher in direct seeded methods than transplanting method in all genotypes interaction with sowing date of December 18. Such difference in number of filled grains might be due to undisturbed (smooth) root establishment in direct seeding method than the transplanted. Among the genotypes PSBRC 82 was found to initiate maximum number of filled grains with least difference of the process between direct seeding and transplanting method. The results thus indicate that genotypes PSBRC 82 in direct seeded condition expressed its best adaptation in respect of sowing on December 18 by minimal differences concerning seedling mortality, spikelet sterility percent, effective tillers per panicle and days to panicle initiation (Table 7).

1000 grain weight (g)

The higher genotypic mean in BRRI dhan36 reveals that among four different genotypes BRRI dhan36 is coarser to others. But from the sowing date mean it was observed that 7th. January sowing exhibits the

higher 1000 grain weight in direct seeding method. In the combined interaction BRRI dhan36 that was sowed on 28th. December represented the highest 1000 grain weight in transplanting methods. Statistical very similar result (26.627 g) was found in BRRI dhan36 that was sowed on 18th December. This result exhibiting the superiority of direct seeding at early sowing than transplanting for obtaining higher yield it is better to sow the seeds on December 18 in direct seeding but December 28th. In transplanting the least significant values (2.74) indicating very strong statistical significant advantages (18 December than 28 December) of direct seeding method than transplanting. This result indicates that the BRRI dhan36 is coarser to that of other three genotypes. The lowest 1000 grain weight (18.150 g) was found in BRRI dhan28 on sowing 18th. December in transplanting condition and (18.816 g) in direct seeding condition, which signify that BRRI dhan28 was finer than that of other genotypes (Table 8).

Grain yield (ton/ha)

Among the varieties studies, the highest yield was found in PSBRC 82 followed by BRRI dhan28where as the lowest grain yield was found in BRRI dhan36. It is to be noted that among four different sowing dates, sowing on 18th. December performed best in respect of yield, and the lowest grain yield was found in sowing on 7th.

January 2010.In direct seeded condition the highest grain yield was found in PSBRC 82 which was sown at 18th. December and significant difference was found in BRRI dhan28. The lowest grain yield was found in BRRI dhan36 sown on 7thJanuaryIt implies that the variety PSBR 82 which was sowed on the 18th December gave the highest grain yield (ton/ha). And the lowest grain yield (1.69 ton/ha) was found in BRRI dhan36sown on 7th January. But except OM 2718, the three other genotypes did not show much more variation between direct seeding and transplanting method. So if OM 2718 was selected for cultivation, than direct seeding method might be used for this genotype. In the combined interaction, the highest genotypic mean (4.548 ton/ha) in PSBRC 82 among the four varieties indicates that PSBRC 82 is more superior to that of other varieties which is statistically similar to BRRI dhan28 (4.462 ton/ha).PSBRC 82 sown on 18th. December produced the highest grain yield (5.900 ton/ha) in direct seeding methods followed by (5.841 ton/ha) in BRRI dhan28 and 5.841 ton/ha in transplanting. The highest yield might be due to low mortality percent, higher number of effective tillers per plant, low spikelet's sterility percent, higher filled grains per panicle and favorable temperature (16-18 °C) in the following interaction. The highest yield is not only due to the genotypes but also the combined action of environments and cumulative effects of all the yield and yield contributing characters. From this table it might be concluded that the interaction between genotype PSBRC 82 and BRRI dhan28 sowing at 18 December for both direct seeding & transplanting methods might be selected for higher yield potentials (Table 9).

Harvest Index (HI)

The highest harvest index was found in PSBRC 82 and the lowest harvest index was found in OM 2718 followed by in BRRI dhan36. Harvest index of boro rice was found to increase in direct seeding than transplanting method due to delay in sowing dates from 8thDecember to 7thJanuary. In direct seeding method such increase in harvest index was recorded to range from 0.392 to 0.412 in BRRI dhan28 up to December 18th and decreased up to January 07th.The higher harvest index in the genotypes PSBRC 82 and BRRI dhan28 in 18th. December

Genotypes	Filled grains (number) per panicle								Mean
	Direct seeding				Transplanting				
	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	
BRRI Dhan 28	131.526	146.739	105.213	101.303	127.625	138.829	116.934	96.403	118.571
BRRI Dhan 36	106.310	129.752	86.113	74.039	112.200	125.842	89.729	62.612	98.325
PSBRC-82	124.333	196.323	128.596	99.372	138.062	192.423	124.685	101.597	138.174
OM-2718	112.700	132.888	91.473	71.021	103.890	119.178	97.363	80.840	101.169
Mean	118.717	148.926	102.849	86.434	120.444	142.568	107.178	85.363	114.068
SE	2.670	5.864	3.478	3.061	2.659	6.850	3.178	3.772	
Lsd	7.35								
CV %	19.171								

SE = Standard Error
Lsd = Least significant difference (Genotype × Methods of Sowing × Date of sowing)
CV % = Co-efficient of variation

Table 7: Filled grains (number) per panicle of four different genotypes at different sowing date's interaction with both direct seeding & transplanting method.

Genotypes	1000-grain weight (g)								Mean
	Direct seeding				Transplanting				
	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	
BRRI Dhan 28	18.881	18.816	20.217	20.756	18.914	18.150	20.531	20.090	19.632
BRRI Dhan 36	25.117	23.804	26.627	25.000	24.451	23.138	26.293	25.960	25.049
PSBRC-82	22.413	21.746	23.059	24.686	21.746	21.080	24.353	24.020	22.888
OM-2718	23.187	21.923	22.863	24.539	22.520	21.256	24.157	23.873	23.040
Mean	22.324	21.322	22.785	24.152	21.658	20.656	23.834	23.486	114.068
SE	1.371	1.258	0.982	1.228	1.371	1.258	1.202	1.228	
Lsd	2.745								
CV %	6.982								

SE = Standard Error
Lsd = Least significant difference (Genotype × Methods of Sowing × Date of sowing)
CV % = Co-efficient of variation

Table 8: 1000-grain weight (g) of four different genotypes in four different sowing date's interaction with both direct seeding and transplanting method.

Genotypes	Grain yield								Mean
	Direct seeding				Transplanting				
	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	
BRRI Dhan 28	4.625	5.841	4.469	2.881	5.341	5.557	4.185	2.597	4.462
BRRI Dhan 36	4.684	4.978	3.685	1.940	4.400	4.204	4.185	1.656	3.717
PSBRC-82	5.264	5.900	4.449	2.920	4.400	5.655	4.361	2.636	4.548
OM-2718	4.782	5.233	3.587	2.038	2.538	2.754	2.323	1.754	3.126
Mean	4.589	5.488	4.047	2.445	4.170	4.543	3.763	2.161	3.913
SE	0.264	0.227	0.239	0.264	0.587	0.587	0.482	0.264	
Lsd	2.74								
CV %	6.982								

Table 9: Grain yield of four different genotypes at different sowing dates interaction with both direct seeding & transplanting method.

Genotypes	Harvest index								Mean
	Direct seeding				Transplanting				
	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	8th Dec/09	18th Dec/09	28th Dec/09	7th Jan/10	
BRRI Dhan 28	0.392	0.412	0.333	0.292	0.333	0.392	0.323	0.263	0.368
BRRI Dhan 36	0.333	0.363	0.323	0.363	0.343	0.323	0.353	0.314	0.339
PSBRC-82	0.333	0.431	0.314	0.221	0.294	0.294	0.314	0.219	0.337
OM-2718	0.323	0.314	0.314	0.214	0.316	0.225	0.225	0.235	0.270
Mean	0.345	0.380	0.321	0.352	0.344	0.309	0.304	0.301	0.372
SE	0.016	0.026	0.005	0.023	0.031	0.035	0.027	0.026	
Lsd	0.03								
CV %	2.331								

SE = Standard Error
Lsd = Least significant difference (Genotype × Methods of Sowing × Date of sowing)
CV % = Co-efficient of variation

Table 10: Harvest index of four different genotypes at different sowing date's interaction with both direct seeding & transplanting method.

might be due to higher accumulation of photosynthates for the favorable temperature and very minimum rainfall and higher sunshine during the active vegetative and panicle initiation stage. The higher panicle initiation was also found in this interaction followed by higher effective tillers, filled grains and biological yield. The increase of harvest index was significant between 8 and 18 and 28 Decemberbut non-significant between 28th December and 7th January in most genotypes. Therefore the increase of harvest index reflects it clearly that harvest index occurs higher in direct seeded methods than transplanting method in all genotypes of boro rice. Such difference in increase of harvest index might be due to the time taken to root establishment of newly transplanted seedlings which was absent in direct seeding method. The lowest harvest index (0.214) was found in OM 2718 at sown on 7th January in direct seeding method. From this table it might be concluded that, PSBRC 82 and BRRI dhan28 in 18 December might be selected for a better contribution in yield (Table 10).

Conclusion

The dwarf plant in delayed seeding indicate the sensitivity of late seeding low temperature on the dry matter production of the genotype unlike other genotypes which expressed no significant reduction in plant height due to late seeding. Significant responses of environments were found either in between the varieties but in between the sowing dates. Maximum number of effective tillers was observed in both direct seeded and transplanted condition in December 18. The tiller number increased with delayed seeding until 18 December but tillers numbers were found to decline afterwards interaction PSBRC 82 took maximum days to flowering sowing at December 08 in transplanting condition but first flowering in direct seeding condition which is statistically different. And the earliest flowering (90.39 days) was observed in BRRI dhan28 sowing at 7 January in direct seeding condition than (93.335 days) in transplanting. PSBRC 82 took the highest days for maturation followed by for OM 2718 whereas the lowest day for maturation was taken by BRRI dhan28. In respect of sowing dates, sowing at 8 December took the highest days for maturation whereas the lowest number taken for maturation was in sowing at January 7. In direct seeded boro rice the highest days to maturity was taken in PSBRC 82 sowing at 8 December while the lowest days to maturity was observed in BRRI dhan28 sowing at 7 January. OM 2718 gave the maximum sterility (43.550) when it was practiced in transplanting method than the direct seeded method (40.701) at January 07. During the germination to seedling stage the severe cold injury affect spikelet's fertility. The increase of filled grains reflects it clearly that the number of filled grains exhibited higher in direct seeded methods than transplanting method in all genotypes interaction with sowing date of December 18. Such difference in number of filled grains might be due to undisturbed (smooth) root establishment in direct seeding method than transplanted. Among the genotypes PSBRC 82 was found to initiate maximum number of filled grains with least difference of the process between direct seeding and transplanting method. The lowest 1000 grain weight (18.150 g) was found in BRRI dhan28 at sowing 18 December in transplanting condition and (18.816 g) in direct seeding condition, which signify that BRRI dhan28 was finer than that of other genotypes. PSBRC 82 sowing at 18 December resulted the highest grain yield (5.900 ton/ha) in direct seeding methods followed by (5.841 ton/ha) in BRRI dhan28 and 5.841 ton/ha in transplanting.

References

1. Wang OP, Srivastava HK (2002) Studies on the nature of relationship between grain size, spikelet number, grain yield and spikelet filling in late duration varieties of rice.*(Oryza Sativa* L) *Plant and Soil* .60: I23-130.

2. Hill AN, Liang MZ, Xiao HH, Chen LB (2002) Correlation analysis between

pollen fertility and panicle exsertion in P(T) GMS rice with eui gene. *Acta-Agronomica-Sinica* 32: 1311-1315.

3. Islam MA, Johora FT, Sarker UK, Mian MAK (2012) Adaptation of Chinese CMS lines interaction with seedling age and row ratio on hybrid seed production of Rice (*Oryza sativa L*) Bangladesh Journal of Agronomy. 25:178-183.
4. Ahmed GJU et al. (2006) Effect of different weed management systems on weed control, plant growth and grain yield of lowland rice 84–93. In: *Weed Science, Agricultural Sustainability and GMOs*, Vol.1, 19th Asian–Pacific Weed Science Society Conference, 17–21 March 2003, Manila, the Philippines.
5. Islam MA, Mian MAK, Rasul G, Khaliq QA, Bashar MK (2013) Estimation of Specific Combining Ability (GCA) Effects and *Per-se* performances in Some Yield Related Traits of Rice (*Oryza sativa* L) Echo-Friendly Agriculture Journal. 7:143-145.
6. Hossain M, Deb UK (2003) Liberalization of Rice Sector: Can Bangladesh withstands Regional Competition? Poster paper presented at PETRRA Communication Fair 2003 held at Hotel Sheraton, Dhaka on Aug. 10-11.
7. Islam MA, Sarker U, Mian MAK (2009) Synchronization and Stability Analysis of Hybrid Seed Production of Rice (*Oryza sativa L*) M. S.Thesis. Department of Genetics and Plant Breeding. Bangabandhu Sheikh Muzibur Agricultural University, Gazipur 1706, Bangladesh.