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Genotypic Variability in Rice for its Suitability for Direct Seeding and Puddled Transplanting

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ABSTRACT

In the present study, a field experiment was conducted to evaluate 10 rice genotypes (three basmati-PB 1121, HB 2 and CSR 30; six coarse grain–HKR 47, HKR 48, HKR 127, HKR 128, PR 121 and PR 122 and one hybrid–HSD 1) for their performance under direct seeding (DSR) and puddled transplanting (PTR). Panicle length, number of grains per panicle, 1000-grain weight and grain yield were significantly higher under PTR than DSR. Among different rice genotypes, plant height, number of tillers and panicle length were higher in basmati genotypes as compared to coarse grain genotypes except HKR 48. On the other hand, dry weight, number of grains per panicle, harvest index and grain yield were higher in coarse grain genotypes. Maximum 1000-grain weight was recorded in genotype PB 1121. Among coarse grain genotypes, highest number of tillers, leaf area index, dry weight, number of effective tillers, 1000-grain weight, harvest index and grain yield were recorded in HKR 48 and plant height in HKR 128. Interaction between establishment methods and rice genotypes indicated that the plant height, number of tillers, leaf area and number of effective tillers of basmati rice genotypes (PB 1121, HB 2 and CSR 30) were higher under DSR than PTR, whereas panicle length, number of grains per panicle, 1000-grain weight and harvest index were higher under PTR than DSR. Grain yield of basmati rice genotypes (PB 1121 and CSR 30) was not affected by methods of planting. The results indicated the suitability of basmati rice genotypes (PB 1121, HB 2 and CSR 30) for direct seeding. There was significant reduction in grain yield of coarse grain genotypes of rice viz., HKR 47, HKR 48, HKR 127, HKR 128, PR 121 and PR 122 under DSR over PTR. Least reduction in grain yield under direct seeding was recorded in coarse grain genotype HKR 48 with maximum grain yield recorded under DSR.

Key words: Rice, direct seeding (DSR), puddle transplanting (PTR), water saving

INTRODUCTION

Rice-wheat system is prevalent in rice growing areas of Haryana. The cropping system is very exhaustive, causing soil and water degradation, deepening of ground water table, multi-nutrient deficiency and associated natural resources degradation. For sustaining the crop productivity in these areas, alternative agro-techniques need to be identified and propagated. New technologies to increase rice productivity will be needed to meet the challenge of enhancing rice production under shrinking cultivable area, water and labour shortages (Goyal *et al*., 2022). Change in traditional method of crop establishment i.e. from puddled transplanting to direct-seeded rice is one of the important and viable options. Direct seeding of rice may be cost-effective and give higher net returns because of lower production cost. Short duration genotypes and efficient water management during early growth stages are some of the key factors needed to get better yield under direct seeding (Khokhar and Sarial, 2018; Wang *et al*., 2021).

Early empirical analyses have indicated that the technical efficiency of rice production is lower and more variable for direct-seeded rice than for transplanted rice. This suggests the existence of a higher "yield gap" between the "best practice" and the average farmer when rice is direct-seeded. A greater variability in the technical efficiency of direct-seeded rice could be partly due to the use of genotypes that were originally developed for transplanted culture. Genotypes that are specifically targeted for direct-seeded methods could help to reduce such yield gaps. However, there are scanty information on comparative performance of genotypes of scented and coarse grain rice as well as hybrids under

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direct seeding and puddled transplanting. The present study was aimed at screening and identifying basmati, coarse grain and hybrid rice genotypes suitable for DSR in rice-wheat cropping system.

MATERIALS AND METHODS

The field experiment was conducted at Karnal which is situated at 245 meters above mean sea level with longitude of $67^0$58′ North and latitude $29^0$43′ East in sub- tropical zone. The weather conditions were normal for the proper growth of rice crop. Mean weekly maximum and minimum temperature fluctuated between 27.1 and 40.7°C and between 8.6 and 28.2°C, respectively. The mean weekly pan evaporation values varied between 2.0 and 9.3 mm. The average total rainfall was recorded to be 486 mm during crop season.

The soil of the experimental field was clay loam in texture, slightly alkaline in reaction, low in available nitrogen and phosphorus and high in available potassium. The experiment was designed as strip plot. The main plot treatment consisted of two methods of crop establishment (Direct-seeded rice-DSR, puddled transplanted rice-PTR) and the sub-plots of 10 rice genotypes (basmati or scented rice-PB 1121, HB 2, CSR 30; coarse grain rice-HKR 47, HKR 48, HKR 127, HKR 128, PR 121, PR 122; hybrid rice–HSD 1) replicated three times. The crop was sown on 10 June under DSR and on 10 July under PTR. The crop was sown 20 cm apart in rows under DSR.

In DSR, the field was dry prepared by giving two harrowing in the month of May and June followed by planking. Two ploughing with disc harrow and one with cultivator followed by planking were given to the vattar field just before drilling of seeds. Twenty kg seed per hectare was used for sowing under DSR. The seeds were soaked in water along with carbendazim (1 g/l water solution/kg seed) for 24 h and then water was completely drained. The seeds were spread and dried for 2 h in shade before sowing. Planking was given after sowing to avoid moisture loss.

In PTR, after harvest of wheat crop, field was given two ploughings with disc harrow each followed by planking in the month of May and June. Then one day before transplanting of rice, fields were flooded with water and puddled by passage of three harrowing followed by planking. Thirty days old seedlings were transplanted manually (one seedling per hill) on 10 July under PTR at row spacing of 20 cm and plant spacing of 15 cm.

Full dose of phosphorus (60 kg/ha for coarse grain rice cultivars and 30 kg/ha for basmati rice cultivars) and $ZnSO_4$ (25 kg/ha) was applied at the time of preparatory tillage by broadcasting under PTR plots. Under DSR plots, $ZnSO_4$ was broadcasted just before seeding and phosphorus was drilled through the sowing drill. Nitrogen (150 kg/ha for coarse grain rice genotypes, 60 kg/ha for basmati rice genotypes and 150 kg/ha for hybrid rice) was applied in three split doses i.e. $1/3^{rd}$ at transplanting, $1/3^{rd}$ at 21 days after transplanting (DAT) and remaining $1/3^{rd}$ at 42 DAT in PTR. Under DSR, N was applied at 21 and 42 days after sowing (DAS).

Plot-wise frequent irrigations were given to maintain the 5±2 cm level of standing water up to 15 days after transplanting. After that irrigation was given as and when required to maintain the saturated conditions of soil. For DSR, first irrigation was given at 7 DAS with follow up irrigations at weekly interval keeping the rainfall in consideration. Irrigation was stopped one week before harvesting of the crop. Pre-emergence herbicide pretilachlor 1.0 kg/ha was applied as broadcast in standing water at 3 DAT for control of weeds in PTR. In DSR, pendimethalin 1.0 kg/ha was applied just after sowing and bispyribac sodium 25 g/ha at 20 DAS as spray in a spray volume of 300 liter water/ha. Manual weeding was also done at 40 DAS/DAT to avoid any infestation of weeds in the crop. The crop was harvested at physiological maturity. All area of 0.5 m on each side of plot and one border row on both side of experimental plots were harvested first, thereafter the net area was harvested separately. The grain yield was recorded at 14% moisture after threshing, cleaning and drying.

RESULTS AND DISCUSSION

Plant population, plant height, effective tillers and dry weight were higher under DSR than PTR (Table 1) due to the fact that seedlings under PTR received transplanting shock which might be the reason of reduction in growth parameters (Sandhu *et al.*, 2019). However, towards maturity, the gap between plant height under the two methods reduced. Contrarily,

Table 1. Effect of different methods of crop establishment and genotypes of rice on yield attributing characters of the crop

Treatment	Effective tillers (No./m.r.l.)	Panicle length (cm)	Plant height (cm)	Grains (No./panicle)	1000-grain weight (g)	Dry weight at maturity (g/m.r.l)
Method of crop establishment						
DSR	59.8	21.5	102.3	82.1	24.8	150.9
PTR	50.9	22.2	87.6	115.6	25.6	138.9
C. D. (P=0.05)	3.01	0.26	11.10	0.44	0.12	30.46
Rice genotypes						
PB 1121	59.3	24.0	99.6	71.5	28.1	144.0
HB 2	57.8	23.4	95.3	68.0	24.8	142.0
CSR 30	56.5	23.5	96.8	64.6	23.7	142.5
HKR 47	53.9	21.0	93.9	111.0	25.2	142.6
HKR 48	57.9	21.5	96.0	110.5	26.6	156.8
HKR 127	50.9	20.9	94.3	113.5	25.5	139.9
HKR 128	53.6	21.0	97.6	113.3	25.5	146.0
PR 121	56.1	20.8	92.0	112.2	23.6	146.3
PR 122	54.1	21.1	92.9	110.9	24.5	144.7
HSD 1	53.5	21.2	90.8	112.7	24.1	144.1
C. D. (P=0.05)	1.87	0.7	4.70	1.63	1.08	10.0

panicle length, number of grains per panicle and higher 1000-grain weight were recorded higher under PTR as compared to DSR which might be due to shorter plant height and fewer number of tillers under PTR, which reduced the competition among tillers and helped in availability of more photosynthates for sink formation i.e. panicle length and number of grains per panicle. Grain and straw yield was higher under PTR as compared to DSR (Table 2). This might be due to higher panicle length, number of grains per panicle and higher 1000-grain weight under PTR than DSR (Table 1; Saha *et al.*, 2020; Quilloy *et al.*, 2021).

Plant population at maturity was recorded higher in genotypes PB 1121 and HKR 48 than the remaining genotypes (Table 1). Genotypes PB 1121, PR 121 and HSD 1 showed higher plant height as compared to other genotypes at 40 DAS. However, at 60 DAS, CSR 30 and HB 2 attained higher plant height than the remaining genotypes. This might be due to the genetic potential of basmati genotypes for taller plants as compared to coarse grain rice genotypes. Among basmati genotypes, PB 1121 attainted higher plant height than CSR 30 and HB 2. Genotype HKR 128 attained highest plant height among the coarse grain genotypes.

Table 2. Effect of different methods of crop establishment and genotypes of rice on grain and straw yield the crop

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
Method of crop establishment			
DSR	5035	6806	42.6
PTR	7211	7156	45.0
C. D. (P=0.05)	87.6	140.7	1.1
Rice genotypes			
PB 1121	4079	5402	43.0
HB 2	3301	4890	40.3
CSR 30	3217	5765	35.8
HKR 47	6327	7603	45.4
HKR 48	6794	7334	48.1
HKR 127	6368	7709	45.1
HKR 128	6745	8789	43.4
PR 121	6390	7697	45.2
PR 122	6365	7545	45.6
HSD 1	5976	7072	45.8
C. D. (P=0.05)	63.1	108.4	0.5

Dry weight was recorded higher in genotype HKR 128 at 40 and 60 DAS, whereas lowest dry weight was recorded in genotype CSR 30 at 40 DAS. At maturity, genotype HKR 48 produced significantly higher dry matter/m.r.l. than the remaining genotypes. The possible reason of lower dry weight produced by the basmati genotypes than the coarse grain genotypes could be due to hollow internodes and thinner diameter of clum of basmati genotypes than coarse grain genotypes. Among the genotypes, PB 1121, HKR 48 and HB 2 produced statistically similar but significantly higher number of tillers than the other genotypes. That's could be due to higher number of tillers produced by these genotypes and lower tiller mortality compared to other genotypes. Genotypes PB 1121, CSR 30, HB 2, HKR 47, HKR 48, HKR 127, HKR 128, PR 121, PR 122 and HSD 1 produced higher number of effective tillers/ m.r.l. under DSR. Panicle length was higher in basmati genotypes as compared to coarse grain genotypes, which may be attributed to loose spikelets and higher staple length as compared to coarse grain genotypes. Higher panicle length was recorded under PTR than DSR in genotypes PB 1121, HKR 127, HKR 128,

Table 3. Interaction effects of methods of establishment and rice genotypes on grain yield (kg/ha)

Methods of crop establishment	Rice genotypes										
	PB 1121	HB 2	CSR 30	HKR 47	HKR 48	HKR 127	HKR 128	PR 121	PR 122	HSD 1	Mean
DSR	4043	3215	3161	5767	6581	5624	6238	5540	5567	5426	5116
PTR	4115	3387	3272	6886	7006	7112	7251	7240	7162	6526	5996
Mean	4079	3301	3217	6327	6794	6368	6745	6390	6365	5976	-
C. D. (P=0.05)											
Methods of crop establishment						87.6					
Rice genotypes						63.1					
Genotypes at same method of crop establishment						77.4					
Methods of crop establishment at same rice genotype						109.6					

PR 121, PR122 and HSD 1. This could be due to the fact that plant height and number of tillers were higher under DSR which resulted in more competition among the plants for assimilates that might have reduced the panicle length (Vishwanath *et al.*, 2021).

Highest 1000-grain weight was recorded in genotype PB 1121, irrespective of two establishment methods. Genotype PB 1121 had higher staple length than the other genotypes, which contributed to its higher 1000-grain weight. Among different genotypes, highest grain yield was recorded in genotype HKR 48 (Table 3) due to higher number of effective tillers, grains per panicle and 1000-grain weight. Grain yield of basmati genotypes (PB 1121 and CSR 30) was at par under DSR and PTR. Similar results were reported by Khokhar and Sarial (2018) and Xu *et al.* (2019).

Harvest index was recorded higher in genotype HKR 48 than the remaining genotypes due to its higher grain yield compared to straw yield (Table 3). As explained earlier, higher grain yield was attributed to higher number of effective tillers, higher number of grains per panicle and higher 1000-grain weight. Harvest index of coarse grain genotypes was higher than the basmati genotypes. Coarse grain genotypes reported to possess potential to give higher grain yield as compared to basmati genotypes.

CONCLUSION

Grain yield of coarse grain rice was poor under DSR and it was not affected by methods of planting in basmati rice, yield penalties in genotype HKR 48 were comparatively less under DSR. Therefore, it may be suggested to the stakeholders to grow basmati rice genotypes under DSR. Since yield reductions in coarse grain genotypes under DSR are substantial, further research may be required to evaluate the suitability of these genotypes at multiple locations.

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