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RESEARCH PAPER

Heterosis in Hybrids between Local and High Yielding Rice (*Oryza sativa* L.) Varieties of Bangladesh

Md. Kamrul Hassan Sohag[1], Md. Shafikur Rahman[2*], Lutfur Rahman[1], S. M. Masiul Azam[1], Khadiza Khatun[2]

[1]Genetic Fingerprinting Laboratory, Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Bangladesh
[2]Faculty, Department of Biotechnology, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh

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*Corresponding author:
shafikjss@gmail.com

ABSTRACT

Heterosis was estimated on hybrids derived after crossing in between three local and three high yielding (HYV) rice varieties. As local rice varieties Kaika Binni, Karaila Dhan and Kachra, and as HYV rice BR23, BRRI Dhan 32, and BRRI Dhan 37 were utilized. Data on plant height, number of total and effective tillers per plant, panicle length, number of total and filled grains per panicle, percent seed set per panicle, 1000 grains weight and weight of grains per panicle of the parents and the hybrids were collected. The average success rate of crossing using HYV varieties as female was 24.46% where the highest cross success (66.25%) was achieved in BRRI Dhan 37 x Kaika Binni. But the reciprocal crosses gave an average of 16.05% success where the highest crossing success was 48.33% in Kachra x BRRI Dhan 32. BRRI Dhan 37 x Kaika Binni showed highest positive heterosis over mid (71.76%) and better parent (58.70%) respectively for number of tillers per hills whereas BRRI Dhan 37 x Karaila Dhan (18.19% of mid parent heterosis) and Kaika Binni x BRRI Dhan 32 (10.59% of better parent heterosis) performed lowest positive heterosis in respect of 1000 grain weight. Among the 18 crosses of the three local and HYV rice varieties, considerable significant positive heterosis were found in few of their F_1 progeny. However, major significant heterosis in terms of yield and yield contributing traits over their mid parent and better parent was observed in F_1 line of BRRI Dhan 37 x Kaika Binni and their reciprocal cross. The outcome of this investigation would be utilized for further development of breeding lines of rice cultivars.

Key words: Heterosis, Local varieties, HYV, *Oryza sativa* L, Bangladesh

Introduction

With the increasing population pressure, the demand of cereal is increasing day by day. Rice is the most important staple food for about two-third of the world's population (Amirjani 2011). It ranks second position by production in the world (Ashikari *et al.* 2005). More than 90% of the rice produced and consumed in Asia as a staple food, which provides 35-60% of the required calories (Sarker *et al.* 2002; Amirjani 2011). The world population is expected to reach at 8 billion in 2025 and 8-9 billion by the year 2030 from the present state of 5.8 billion and it is estimated that 50% more food will be required to feed the increased population (Brown 1994; Khush 1998 and 2005; Amirjani 2011; Ashikari *et al.* 2005, Srividya *et al.* 2010). Bangladesh ranks third among the rice producing countries of the world though yield is relatively lower than the other countries. So, in Bangladesh, developing genotypes with high yield potential is one of the important ways to meet the future demand. Rice is considered as a major crop in Bangladesh as it constitutes 94.38% of the total food grain (rice & wheat) production of 26.7 million metric tons (Iftekharuddaula *et al.* 2008).

Hybrid rice offers an opportunity to boost the yield potential of rice. It has a yield advantage of 15-20% over conventional high yielding variety (Virmani *et al.* 1993). Hybridization offers far greater possibilities in crop improvement than any other breeding method and is the predominant means of combining desirable characters of two or more varieties (Widyastuti 2017). Therefore, there is a possibility of combining most of the desirable characters from the high yielding apparently introduced rice and the local varieties into one genotype through hybridization (Srividya *et al.* 2010). The breeding of quantitatively better rice varieties is not possible without prior knowledge of their genetic properties. The breeders therefore try, with the help of suitable genetic

method to combine the desired properties of different varieties (Swamy *et al.* 2003).

The term heterosis, also known as hybrid vigor, describes the increased strength of different characteristics in hybrids; the possibility to obtain a genetically superior individual by combining the virtues of its parents (Virmani *et al.* 1993). Heterosis is the opposite of inbreeding depression, which occurs with increasing homozygosity. Generally, there can be high heterosis over mid parent or even over better parent when there is a high genetic difference exists between the parents (Hooker 2012). High yielding rice varieties and traditional rice cultivars have high genotypic as well as phenotypic difference. So, there might be a chance to explore desirable heterosis if there is works with high heterosis cross combination (Richhari and Singh 1983).

In this study, quality F_1 progenies among the crosses between the local and BRRI released HYV cultivars have been identified with taking into consideration of yield and yield attributed traits such as plant height, number of total and effective tillers per plant, panicle length, and number of total and filled grains per panicle, percent seed set per panicle, 1000 grains weight and weight of grains per panicle. Hybrid rice of the superior heterosis usually provides the important avenue through which the higher yields can be achieved. Thus, the information in this study might be helpful to the breeders for genetic improvement of the existing genotypes on the basis of the performance in various hybrid combinations.

Materials and Methods

Locations, materials and the cross combinations

The experiment was conducted at the net house of the Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh, during the Aman season. The materials used in the experiment were three BRRI rice varieties, viz. BR 23, BRRI Dhan 32, BRRI Dhan 37, and three local varieties, viz. Kaika Binni, Karaila Dhan and Kachra were collected from the Genetic Resource and Seed (GSD) division of Bangladesh Rice Research Institute (BRRI). Accession numbers, parental lines and their details of these six cultivars can be found from the published research manuscripts of Rahman *et al.* 2008a and 2008b. The parental materials were grown in earthen pots for crossing. Crossing between the local rice cultivars and the BRRI rice varieties with their reciprocals was performed, and in such way a total of 18 crosses were possible. Performances of their F_1 lines along with parents were assessed. However, crossing was done soon after flowering began in both the local and high yielding varieties of rice. The standard clipping technique was used in crossing among the parents. Emasculation was done after 3 p.m. every day in the selected female parents. Time of blooming was dependent on weather conditions. In favorable weather anthesis began at about 8 a.m. and continued until noon. The spikelets in which anthers were yellow and reached the middle of the spikelets were selected for emasculation, as they were expected to bloom in the following morning. Anthers were removed from the spikelets with tip of a fine forceps taking care that the stigma and the ovary did not get any injury. After emasculation the whole panicle was covered with a cellophane bag to avoid pollination from foreign pollens. After this a tag containing the name of the emasculated variety, date of emasculation, no of spikelet emasculated were hanged from the stick.

On the following morning between 8.00 a.m. to 11.30 a.m. anthers were carefully brushed against the emasculated floret to cause pollen shedding onto the stigma. After completion of pollination the panicle was properly labeled and re-bagged still remaining the flag leaf inside the bag. The forceps were dipped in rectified spirit between crosses to prevent contamination. Another method was also followed for pollination. In this case the panicle with pollen was cut carefully from the male parent and shaded over the emasculated panicle. The bags were removed after 7 days of pollination. The date of pollination, the number of flowers pollinated and the number of seed sets were recorded for each cross combination. Completely ripened F_1 seeds were harvested and kept in paper bags separately. The F_1's seeds were then air dried and kept in the cold room (12 ^{0}C) for growing in the next season.

Culture of parents and F_1 plants

Seeds of parent varieties along with that of the F_1 were placed on moist filter papers contained in petri-dishes and left at room temperature. Germinating seeds were transferred to pots of 24 cm diameter. Thirty day-old seedlings of each cross combination and the parental lines were transplanted in the pots with three replications. Each pot contained 3 seedlings of respective crosses and parent varieties. Intercultural operations, such as weed control, water management, fertilizer and pesticide application were followed.

Collection of data and their analyses

The following quantitative characters of parents and F_1 plants were studied through recording of data on plant height, Total and effective tillers per plant, panicle length, number of totals and filled grains/ panicle, percent seed set per panicle, weight of grains per panicle and 1000 grains weight. Analysis of variance was performed using the Plant Breeding Statistical Program (PLABSTAT, Version 2N, Utz 2011) with the following model: $Y_{ij}= \mu+ g_i+ r_j + \varepsilon_{ij}$ Where, Y_{ij} was observed of genotype *i* in replicate *j*; g_i and r_j were the effects of genotype *i* in the replicate *j*, respectively and ε_{ij} was the residual error of genotype *i* in replicate *j*. The replicates were considered as random variable. Cross ability was measured by using the following formula:

$$\text{Cross ability}= \frac{No.of\ seed\ \ formed}{No.of\ crossed\ \ spikelet} \times 100.$$

The amounts of heterosis in the F_1 were estimated using standard formula (Birchler *et al.* 2010). The test of significance was also made by using paired *t*-test.

Results and Discussions

Mean values of plant height, number of tillers per hill, number of effective tillers per hill, panicle length, number of spikelet per panicle, number of kernel per panicle, percent sterile spikelet per panicle, 1000 grain weight, weight of grains per panicle, yield per plant of parent and hybrids of all possible cross combinations

along with percent of positive and negative heterosis on F_1 line over mid parent and better parent were determined (Table 1 and Table 2). However, percent of positive heterosis was taken into consideration for describing the positive attributes in this study.

Plant height

The hybrids of Kaika Binni x BIRI Dhan 37 showed the highest positive heterosis over mid parent (25.94%) and better parent (34.49) followed by the hybrid of BRRI Dhan 32 x Kachra, BR 23 x Kachra (Over the mid parent showed in the Table 1) and BR 23 x Kaika Binni, BR 23 x Kachra (Over better parent, Table 1). However, some crosses showed high negative heterosis over mid parent and better parent.

Tiller number per hill

The F_1 of BRRI Dhan 37 x Kaika Binni showed the highest positive heterosis over mid parent (71.76% in the Table 1) and better parent also (58.70% in the Table 1). It was followed by the cross Kaika Binni x BRRI Dhan 37, Karaila Dhan x BR 23, Karaila Dhan x BRRI Dhan 37 , BR 23 x Kaika Binni. High negative heterosis over mid parent and better parent also has been found in the some crosses.

Effective tiller number per hill

The F_1 of Kaika Binni x BRRI Dhan 37 , BRRI Dhan 37 x Kaika Binni showed the highest positive heterosis over mid parent and better parent, the values of which were 63.16% and 51.22% respectively (Table 1). It was followed by the cross Karaila Dhan x BR 23, BR 23 x Kaika Binni, Karaila Dhan x BRRI Dhan 37, BRRI Dhan 37 x Kachra, Kachra x BRRI Dhan 32, Kaika Binni x BRRI Dhan 32.

Panicle length

The F_1 of BRRI Dhan 37 x Karaila Dhan showed the highest positive heterosis (28.06%) over mid parent followed by the BRRI Dhan 37 x Kaika Binni, Karaila Dhan x BRRI Dhan 32, and Karaila Dhan x BRRI Dhan 37 (Table 1). BRRI Dhan 37 x Kaika Binni showed the highest positive heterosis (21.06%) over better parent (Table 1) followed by the cross of BRRI Dhan 37 x Kaika Binni, Karaila Dhan x BRRI Dhan 32, Karaila Dhan x BRRI Dhan 37. Very weak whether positive or negative heterosis indicates absence of any genetic difference for this trait. In respect of this trait such crosses were BR 23 x Karaila Dhan and BR 23 x Kachra etc.

Number of spikelet per panicle

The F_1 of Kaika Binni x BRRI Dhan 37 (Table 1) showed the highest positive heterosis over mid parent (33.72%) and better parent (23.98%) followed by the crossing of BRRI Dhan 37 x Kaika Binni, Karaila Dhan x BRRI Dhan 32, BRRI Dhan 32 x Kachra, BR 23 x Kaika Binni, Karaila Dhan x BRRI Dhan 37 (Table 1). High negative heterosis over mid parent and better parent also has been found among some crosses of Karaila Dhan x BR 23, Kachra x BRRI Dhan 32.

Number of kernel per panicle

The F_1 line of BRRI Dhan 37 x Kaika Binni (Table 2) showed the highest positive heterosis over mid parent (40.00%) and better parent (25.10%). The positive heterosis was also followed in these crosses by the F_1 line of Kaika Binni x BRRI Dhan 37 , Karaila Dhan x BRRI Dhan 32, BRRI Dhan 32 x Kachra, BR 23 x Kaika Binni, BR 23 x Kachra, Karaila Dhan x BRRI Dhan 37, BRRI Dhan 37 x Karaila Dhan, Kachra x BRRI Dhan 37 .

Percent sterile spikelet per panicle

The F_1 of Karaila Dhan x BR 23 showed the highest positive heterosis (42.48%) over mid parent (Table 2). It was followed by the crossing of Kachra x BRRI Dhan 32, BRRI Dhan 32 x Kaika Binni. The F_1 of Karaila Dhan x BR 23 showed the highest positive heterosis (46.11%) over better parent (Table 2). It was followed by the crossing of BRRI Dhan 32 x Kaika Binni, Kachra x BRRI Dhan 32.

1000 grain weight

The F_1 of BRRI Dhan 37 x Karaila Dhan showed the highest positive heterosis (18.19%) over mid parent (Table 2). It was followed by the crossing of Kachra x BRRI Dhan 37, BRRI Dhan 32 x Kachra, Kachra x BRRI Dhan 32, Kaika Binni x BRRI Dhan 32, BR 23 x Karaila Dhan, BRRI Dhan 32 x Karaila Dhan. The F_1 of Kaika Binni x BRRI Dhan 32 showed the highest positive heterosis (10.59%) over better parent (Table 2). It was followed by the cross BRRI Dhan 32 x Kachra, Kachra x BRRI Dhan 32, BRRI Dhan 37 x Karaila Dhan, BR 23 x Karaila Dhan.

Weight of grains per panicle

The F_1 of Kaika Binni x BRRI Dhan 37 (Table 2) showed the highest positive heterosis over mid parent (53.17%) and better parent (50.51%). The positive heterosis was also followed in these crosses by BRRI Dhan 32 x Kachra, BRRI Dhan 37 x Kaika Binni, Kachra x BRRI Dhan 37, BRRI Dhan 37 x Karaila Dhan, Karaila Dhan x BRRI Dhan 32, BR 23 x Kaika Binni.

The percent of heterosis in the F_1 line over mid parent and better parent for plant height, tiller number per hill, effective tiller number per hill, panicle length and spikelet per panicle, number of kernel per panicle, percent sterile spikelet per panicle, 1000 grain weight and weight of grains per panicle were estimated and presented in Table 1 and Table 2. Significant values of percent heterosis from the paired t-test analysis represent differences among crosses among three local and three HYV rice varieties for all yields and yield related characters that revealed wide range of variation for the parents and hybrid lines. Similar results of genotypic differences were also observed by Ganesen and Rangaswamy (1997) in number of panicle per hill and panicle length correlated traits. The degree of heterosis varied from cross to cross and even from character to character (Sarker *et al.* 2002). Pathak and Sanghi (1992) in sorghum and Patel *et al.* (1994) in upland rice also obtained varying percent heterosis for yield and its related traits. Negative heterosis is only desirable in case of days to maturity of a plant but for rest of the agronomic traits positive heterosis should be firmly desirable attributes (Sarker *et al.* 2002). In this study, negative percent heterosis was also found all through nine characters (Table 1 and Table 2). It might be due to local convexity (Fiévet *et al.* 2018) or unseasonal cultivation or management practices of impractical cross specific materials (George 2008). However, typical positive heterosis ranges 34.49 to 25.94%, 58.70 to 71.76%, 51.22 to 63.16%, 21.05 to 28.06%, 23.98 to 33.72%, 25.10 to 40.00%, 29.69 to 62.48%, 10.59 to 18.19% and 50.51-53.17% for plant height, number of tillers per hill, number of effective tillers per hill, panicle length, number of spikelet per panicle, number of kernel per panicle, number of sterile spikelet per panicle 1000 grain weight and weight of grains per panicle respectively (Table 3).

Table 1: Percent heterosis in F_1 over mid parent and better parent for plant height, tiller number per hill, effective tiller number per hill, panicle length and spikelet per panicle.

Parents and F_1	% Heterosis in F_1 for plant height			% Heterosis in F_1 for tiller number per hill			% Heterosis in F_1 for effective tiller number per hill			% Heterosis in F_1 for panicle length			% Heterosis in F_1 for spikelet per panicle		
	Mean value (cm)	Over mid parent	Over better parent	Mean value	Over mid parent	Over better parent	Mean value	Over mid parent	Over better parent	Mean value (cm)	Over mid parent	Over better parent	Mean value	Over mid parent	Over better parent
BR 23	70.00			17.33			15.67			27.33			202.67		
BRRI Dhan 32	95.67			19.67			16.67			24.67			184.33		
BRRI Dhan 37	108.67			15.33			13.67			25.33			187.67		
Kachra	86.33			10.33			9.00			26.33			200.67		
Karaila Dhan	95.33			20.33			17.67			21.00			166.00		
Kaika Binni	95.67			13.00			11.67			23.33			160.33		
BR 23 x Kachra	90.33	15.57*	29.05*	13.33	-3.61	-23.08	11.67	-5.41	-25.53	26.33	-1.86	-3.66	222.67	10.41	9.87
BR 23 x Karaila Dhan	90.33	9.27	19.07	15.33	-18.58	-24.59	14.00	-16.00	-20.75	24.33	0.69	-10.98	152.67	-17.18	-24.67
BR 23 x Kaika Binni	93.33	12.68	33.33**	19.33	27.47	11.54	16.67	21.95*	6.38	26.67	5.26	-2.44	208.67	14.97	2.96
Kachra x BR 23	57.33	-1.55	-1.47	12.67	5.3	13.07	11.00	11.56	13.07	15.33	-02.84	-3.69	103.33	-18.27	-12.35
Karaila Dhan x BR 23	68.00	-17.74	-2.86	27.33	45.13*	34.43*	23.33	40.00*	32.08**	20.67	-14.48	-24.39	123.00	-33.27	-39.31
Kaika Binni x BR 23	44.66	-3.57	-1.33	14.67	5.31	11.19	13.66	14.33	8.19	14.67	-4.44	-5.73	109.33	-16.34	-10.35
BRRI Dhan 32 x Kachra	108.33	19.05*	25.48	12.33	-17.78	-37.29	10.67	-16.88	-36.00	28.67	12.42	8.86	227.67	18.27*	13.46
BRRI Dhan 32 x Karaila Dhan	92.67	-2.97	-2.80	15.00	-25.00	-26.23	13.00	-24.27	-26.42	26.67	16.79	8.11	151.33	-13.61	-17.90
BRRI Dhan 32 x Kaika Binni	100.67	5.23	5.23	14.33	-12.24	-27.12	12.33	-12.94	-26.00	20.67	-13.89	-16.22	103.33	-40.04	-43.94
Kachra x BRRI Dhan 32	87.67	3.66	1.54	16.33	8.89	-16.95	14.67	14.29	-12.00	20.00	-21.57	-24.05	123.67	-35.76	-38.37
Karaila Dhan x BRRI Dhan 32	98.67	3.32	3.50	19.33	-3.33	-4.92	16.67	-2.91	-5.66	28.00	22.63**	13.51*	219.33	25.21**	18.99**
Kaika Binni x BRRI Dhan 32	100.33	4.88	4.88	17.67	8.16	-10.17	15.67	10.59	-6.00	22.00	-8.33	-10.81	140.00	-18.76	-24.05
BRRI Dhan 37 x Kachra	101.00	3.59	16.99	15.33	19.48	0.00	13.00	14.71	-4.88	30.00	16.13	13.92*	199.67	2.83	-0.50
BRRI Dhan 37 x Karaila Dhan	112.67	10.46	18.18	16.33	-8.41	-19.67	14.00	-10.64	-20.75	29.67	28.06***	17.11**	192.00	10.34	2.31
BRRI Dhan 37 x Kaika Binni	102.33	0.16	6.97	24.33	71.76**	58.70**	20.67	63.16***	51.22***	30.67	26.03***	21.06**	231.67	33.14***	23.45***
Kachra x BRRI Dhan 37	110.67	13.50	28.19*	13.33	3.90	-13.04	11.33	0.00	-17.07	29.33	13.55	11.39**	197.00	1.46	-1.83
Karaila Dhan x BRRI Dhan 37	100.33	-1.63	5.24	25.00	40.19*	22.95	18.67	19.15	5.66	28.33	22.30*	11.84*	199.33	14.56	6.22
Kaika Binni x BRRI Dhan 37	128.67	25.94**	34.49***	23.67	67.06**	54.35**	20.67	63.16***	51.22***	27.67	13.70*	9.21	232.67	33.72***	23.98***

Note: *,** and *** indicate significant at 5%, 1% and 0.1% level of probability respectively

Table 2: Percent heterosis in F_1 over mid parent and better parent for number of kernel per panicle, percent sterile spikelet per panicle, 1000 grain weight and weight of grains per panicle

Parents and F_1	% Heterosis in F_1 for number of kernel per panicle			% Heterosis in F_1 for percent sterile spikelet per panicle			% Heterosis in F_1 for 1000 grain weight			% Heterosis in F_1 for weight of grains per panicle		
	Mean value	Over mid parent	Over better parent	Mean value	Over mid parent	Over better parent	Mean value (g)	Over mid parent	Over better parent	Mean value	Over mid parent	Over better
BR 23	183.00			9.72			22.90			3.28		
BRRI Dhan 32	169.00			8.34			18.40			2.54		
BRRI Dhan 37	175.33			6.57			15.03			2.22		
Kachra	163.67			18.43			21.07			2.75		
Karaila Dhan	145.67			12.21			19.97			2.65		
Kaika Binni	138.00			13.91			20.20			2.30		
BR 23 x Kachra	199.33	15.00	8.93	10.34	-26.56	6.37	19.81	-9.88	-13.49	3.17	5.09	-3.36
BR 23 x Karaila Dhan	139.33	-15.21	-23.86	8.67	-20.85	-10.71	23.23	8.37	1.43	2.50	-15.59	-23.70
BR 23 x Kaika Binni	189.67	18.17	3.64	9.10	-22.98	-6.35	21.21	-1.57	-7.38	3.33	19.47	1.73
Kachra x BR 23	56.67	-14.29	-0.33	8.67	20.14	28.69	12.67	-0.33	-2.86	0.32	-19.43	-11.18
Karaila Dhan x BR 23	87.67	-46.65	-52.09	28.77	42.48**	46.11***	21.31	-0.60	-6.97	1.77	-40.35	-46.08
Kaika Binni x BR 23	67.33	-33.32	-13.42	11.87	20.21*	10.34	17.67	-0.36	-1.89	0.42	-21.32	-8.18
BRRI Dhan 32 x Kachra	211.00	26.85*	24.85**	7.32	-45.34*	-12.29	22.22	12.60**	5.47**	3.63	37.28***	32.12**
BRRI Dhan 32 x Karaila	134.00	-14.83	-20.71	11.37	10.67	16.30	20.07	4.60	0.50	2.20	-15.22	-16.88
BRRI Dhan 32 x Kaika	89.00	-42.02	-47.34	13.94	25.24*	37.05**	18.87	-2.25	-6.60	1.57	-35.35	-38.40
Kachra x BRRI Dhan 32	97.00	-41.68	-42.60	21.58	31.22**	28.69	22.12	12.08**	4.98**	1.77	-33.25	-35.76
Karaila Dhan x BRRI	206.33	31.14**	22.09**	5.84	-43.17	-30.01	17.53	-8.62	-12.20	3.13	20.75**	18.39**
Kaika Binni x BRRI	129.67	-15.53	-23.27	7.33	-34.14	-12.16	21.34	10.59*	10.59***	2.33	-3.71	-8.26
BRRI Dhan 37 x Kachra	169.00	-0.29	-3.61	15.08	20.68*	19.69	17.30	-4.14	-17.86	2.27	-8.85	-17.58
BRRI Dhan 37 x Karaila	176.00	9.66	0.38	8.33	-11.21	26.91	20.68	18.19***	3.59	3.10	27.31*	17.13**
BRRI Dhan 37 x Kaika	219.33	40.00***	25.10***	5.35	-47.77	-18.57	16.74	-4.98	-17.13	3.10	36.97***	34.59***
Kachra x BRRI Dhan 37	177.67	4.82	1.33	9.80	-21.60	27.23	20.34	12.67**	-3.47	3.17	27.35**	15.15**
Karaila Dhan x BRRI	184.00	14.64	4.94	7.67	-18.32	16.74	16.62	-5.05	-16.78	2.57	5.41	-3.02
Kaika Binni x BRRI	218.33	39.36***	24.52**	6.22	-39.26	-5.29	18.41	4.50	-8.86	3.47	53.17***	50.51***

Note: *,** and *** indicate significant at 5%, 1% and 0.1% level of probability respectively

Table 3: Maximum heterosis over mid and better parent found for different characters

Characters	Maximum heterosis over mid parent		Maximum heterosis over better parent	
	F_1 line	% of heterosis	F_1 line	% of heterosis
Plant height	Kaika Binni x BRRI Dhan	25.94%	Kaika Binni x BRRI	34.49%
Number of tillers per hill	BRRI Dhan 37 x Kaika	71.76%	BRRI Dhan 37 x Kaika	58.70%
Number of effective tillers per	BRRI Dhan 37 x Kaika	63.16%	Kaika Binni x BRRI	51.22%
Panicle length	BRRI Dhan 37 x Karaila	28.06%	BRRI Dhan 37 x Kaika	21.06%
Number of spikelet per panicle	Kaika Binni x BRRI Dhan	33.72%	Kaika Binni x BRRI	23.98%
Number of kernel per panicle	BRRI Dhan 37 x Kaika	40.00%	BRRI Dhan 37 x Kaika	25.10%
Percent of sterile spikelet per	Karaila Dhan x BR 23	42.48 %	Karaila Dhan x BR 23	46.11%
1000 grain weight	BRRI Dhan 37 x Karaila	18.1 %	Kaika Binni x BRRI	10.59 %
Weight of grains per panicle	Kaika Binni x BRRI Dhan	53.17%	Kaika Binni x BRRI	50.51%

The average success rate of crosses using HYV varieties as female was 24.46% where the highest cross success (66.25%) was achieved in BRRI Dhan 37 x Kaika Binni. But the reciprocal crosses gave on an average of 16.05% success where the highest cross success was 48.33% in Kachra x BRRI Dhan 32.

Highest heterosis is found in BRRI Dhan 37 x Kaika Binni (71.76% and 58.70%) for number of tillers per hill, Kaika Binni x BRRI Dhan 37 (53.17% and 50.51%) for weight of grains per panicle, Karaila Dhan x BR 23 (42.48% and 46.11) for percent of sterile spikelet, BRRI Dhan 37 x Kaika Binni (40.00% and 25.10%) for number of kernel per panicle, Kaika Binni x BRRI Dhan 37 (25.94% and 34.49%) for plant height and Kaika Binni x BRRI Dhan 37 (33.72% and 23.98%) for number of spikelet per panicle over both mid and better parent from the same varietal cross. On the other hand, some unrelated varietal crosses like BRRI Dhan 37 x Kaika Binni (63.16%) and Kaika Binni x BRRI Dhan 37 (51.22%) for number of effective tillers per hill; BRRI Dhan 37 x Karaila Dhan (28.06%) and BRRI Dhan 37 x Kaika Binni (21.06%) for panicle length; and BRRI Dhan 37 x Karaila Dhan (18.19%) and Kaika Binni x BRRI Dhan 32 (10.59%) for 1000 grain weight also showed desirable positive heterosis over mid and better parent respectively.

Conclusion

A total of 18 crosses between three local and three HYV rice varieties with their reciprocals in respect of yield and yield attributed traits have been analyzed. These local and HYV rice cultivars were to be selected to investigate any superior positive heterosis among the crosses. However, the significant and considerable heterosis is found in all through crosses. The F_1 line of BRRI Dhan 37 x Kaika Binni and their reciprocal cross of Kaika Binni x BRRI Dhan 37 performed major positive and significant heterosis over mid parent and better parent across the crosses. Yield is the complex characters of all other yield contributing characters. So, these F_1 lines might be considered for the further study of combining ability test.

References

Amirjani MR (2011) Effect of salinity stress on growth, sugar content, pigments and enzyme activity of rice. *International Journal of Botany* **7(1)**: 73-81. https://doi.org/10.3923/ijb.2011.73.81

Ashikari M, Sakakibara H, Lin S, Yamamoto T and Takashi T (2005) Cytokinin oxidase regulates rice grain production. *Science* **309**: 741-745. https://doi.org/10.1126/science.1113373

Birchler JA, Yao H, Chudalayandi S, Vaiman D, Veitia RA (2010) Heterosis. *The Plant Cell* **22(7)**:2105-12. https://doi.org/10.1105/tpc.110.076133

Brown LR (1994) *State of the world*. W. W. Norton and Company, New York.

Fiévet B *et al*. (2018). Heterosis Is a Systemic Property Emerging From Non-linear Genotype-Phenotype Relationships: Evidence From in Vitro Genetics and Computer Simulations. *Frontiers in Genetics* 9. https://dx.doi.org/10.3389/fgene.2018.00159

Ganesen K N and Rangaswamy M (1997). Heterosis in rice hybrids bred with wild abortives source of CMS lines. *Crop Research* 13(3): 603-607.

George RP (2008). *Encyclopedia of Genetics, Genomics, Proteomics and Informatics*. 10.1007/978-1-4020-6754-9_2. https://doi.org/10.1007/978-1-4020-6754-9

Hooker JD (2012) *The flora of British India*. Vol. 2L. Reeve Co. Kent, England. https://doi.org/10.5962/bhl.title.54393

Iftekharuddaula K, Newaz MA & Salam MA &Akter K. (2009). Genetic analysis for panicle characters in diallel cross of rice. *Bangladesh Journal of Agricultural Research*. 33. 10.3329/bjar.v33i4.2307. https://doi.org/10.3329/bjar.v33i4.2307

Khush GS (1998) *Strategies of increasing crop productivity*. In: V. L. Chopra, R. B. Singh and A. Verma (eds). Crop productivity and sustainability. Proceedings of the 2nd International Crop Science Congress. Oxford and IBM PublishingCo. Pvt. Lts. New Delhi, India, p. 19.

Khush GS (2005) What it will take to feed five billion rice consumers by 2030. *Plant Molecular Biology* 59: 1-6. https://doi.org/10.1007/s11103-005-2159-5

Patel PIR, Patel S and Desani MS (1990) Heterosis and combining ability of grain sorghum at different location in gujarat. *Indian Journal of Agricultural science* **60(6)**: 382- 386.

Pathak H C and Sangh AK (1992) Genetic analysis of leaf and physiological traits in forage sorghum

across environments. *Gujarat Agricultural University research Journal* **17(2)**: 49-55.

PLABSTAT (Version 2N) Utz HF (2011) A computer program for the computation of variances and covariances. Institute of Plant Breeding, Seed Science and Population Genetics, University of Hohenheim, Stuttgart, Germany. (http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Plabstat#1).

Rahman L, Alam MS, Hassan L, Alam MS, Bashar MK, Rahman MS, et al. Rice Varieties of Bangladesh: Morphological and Molecular Characterization. Vol 1. Published by Seed Wing, Ministry of Agriculture, Government of the People's Republic of Bangladesh; 2008. DOI: 10.13140/RG.2.1.3160.9684

Rahman L, Rahman MS, Islam MN, Islam MS. Rahman L, Islam MN, Rahman MS, Islam MS. Plant Varieties of Bangladesh: Morphological and Molecular Characterization. Vol 2. Published by Seed Wing, Ministry of Agriculture, Govt of the People's Republic of Bangladesh; 2008; 2:300. https://www.researchgate.net/publication/286146036_PLANT_VARIETIES_OF_BANGLADESH_Morphological_and_Molecular_Characterization_Volume-2.

Rahman MA, Kwon YJ, Suh SJ (2012) Two new species of the genus *Vekunta* Distant (Hemiptera: Fulgoromorpha: Derbidae) from Korea. *Zootaxa* **3313**:23-33. http://dx.doi.org/10.11646/zootaxa.3313.1.3

Richhari AK and Singh RS (1983) *Heterosis in relation to per se performance and effects of general combining ability in rice*. Progresses scientific meeting on genetics and improvement of heterotic systems, Coimbatore, India.

Sarker U, Rasul M &Mian MAK (2002) Heterosis and Combining Ability in Rice. *Bangladesh Journal of Plant Breeding and Genetics* **15(1)**: 17-26.

Srividya A, Vemireddy LR, Hariprasad AS, Jayaprada M and Sridhar S (2010) Identification and mapping of landrace derived QTL associated with yield and its components in rice under different nitrogen levels and environments. *International Journal of Plant Breed* and Genetics ***4***: 210-227. https://dx.doi.org/10.3923/ijpbg.2010.210.227

Swamy MH, Gururaja Rao MR and Vidyachandra B (2003) Studies on combining ability in rice hybrids involving new CMS lines. Karnataka. *Journal of Agricultural Science* **16(2)**: 228-233.

Virman SS Prasad MN and Kumar J (1993) *Breaking the yield barrier of rice through exploitation of heterosis*. In. Murlidharan K, Siddiq E A, editors. New frontiers in rice research. Hyderabad (India): Directorate of Rice Research. Pp 76-85.

Widyastuti Y (2017). Prediction of Combining Ability and Heterosis in the Selected Parents and Hybrids in Rice (*OryzaSativa*.L). *Informatika Pertanian*31-40. 26. 31. 10. 21082/ip.v26n1.2017. https://dx.doi.org/10.21082/ip.v26n1.2017.p31-40

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