Research Article

Heritability and Heterosis for Yield and Yield Related Traits in Rice

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Abstract | This research was carried out to assess heritability and heterosis among 30 rice genotypes for yield and related parameters at The University of Agriculture Peshawar-Pakistan, during 2011. Thirty rice genotypes including 14 parents and 16 F_1 hybrids were replicated twice in a randomized complete block design (RCBD). Rice genotypes reflected significant differences ($P \leq 0.01$) for all the traits. Among the rice parents, Bas-6129 and Bas-370 showed the highest values for grains panicle^{-1} (214.0) while IR-8 displayed maximum values for spikelets panicle^{-1} (238.0), 1000-grain weight (30.9 g) and grain yield (0.97 kg m^{-2}). F_1 hybrids Dokri-Bas/Bas-6129, DR-92/DR-83, Bas-2008/Kashmir-Bas, IR-8/NIAB-IR-9 and Bas-6129/Dokri-Bas produced maximum spikelet's panicle^{-1} (270.0), grains panicle^{-1} (233.0), 1000-grain weight (31.5 g) and grain yield (0.83 kg m^{-2}), respectively. Maximum values of phenotypic and genotypic coefficient of variations (PCV and GCV) were displayed by the genotypes for grain yield. The rice genotypes manifested high heritability in broad sense for the traits in study except grains panicle^{-1}. F_1 hybrid DR-92/DR-83 exhibited maximum better parent heterosis for spikelets panicle^{-1} (32.3%) and grains panicle^{-1} (45.1%) while F_1 hybrid combinations Bas-2008/Kashmir-Bas and Bas-6129/Dokri-Bas for 1000-grain weight (18.9%) and grain yield (50.0%). Rice parents IR-8, Bas-6129 and Bas-370, based on their excellence for yield and yield related parameters, are recommended for use in future rice hybridization programs while the F_1 cross combinations DR-92/DR-83, Bas-6129/Dokri-Bas and Bas-2008/Kashmir-Bas are recommended to develop advance generations and improved rice varieties.

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Introduction

Rice (*Oryza sativa* L.) has a significant role amongst the cereal crops and is grown in diverse agro-ecological environments worldwide. It provides food to the maximum population of the world particularly the developing countries heavily depends upon its calories and protein. The phenomenon of superior performance of F_1 for most of the desired traits over its parents is termed as heterosis or vigour. Heterosis is considered the major achievement of most crop breeding programs and this phenomenon is widely used in different crops (Birchler et al., 2003). Jones (1926) first observed the phenomenon of heterosis by observing that F_1 rice hybrids produced increased tillers and higher yield than their parental genotypes. Heterosis for a trait could be both positive and negative while the desired value of heterosis is dependent on the nature of the particular trait. Heterosis when observed positive is used for grain yield, whereas, negative heterosis is used for early maturity (Nuruzzaman et al., 2002). Availability of genetic variation, its nature and magnitude is of prime importance to improve genetically the grain yield and related parameters of crop plants (Fisher, 1981; Babu et al., 2012).

The degree of genetic variation in a population of crop plants is measured by the coefficient of variations of phenotype and its genotype (PCV and GCV) that provide valuable information about the variability for different traits (Roychowdhury and Tah, 2011). PCV is the proportionate standard deviation of phenotypic value to overall mean whereas GCV is the proportionate standard deviation of genotypic value to overall mean. Higher PCV value than the corresponding GCV values for a trait depicts that the major proportion of phenotypic variation is constituted by the environmental variance (Sunday et al., 2007). Heritability in broad sense can be defined as, the ratio of total genetic variance (additive, dominance and epistatic) to the phenotypic variance (Falconer and Mackay, 1996). High heritable traits have smaller environmental influence and the traits having low heritability are highly influenced by the environmental fluctuations (Bhadru et al., 2012). The present study was focused on assessment of heterosis and heritability among F_1 rice hybrids for yield and yield-related traits.

Materials and Methods

This study was performed in the Research Farm of The University of Agriculture Peshawar-Pakistan, during the year 2011. Thirty rice genotypes including 16 F_1 rice hybrids and their 14 parents were replicated twice in a randomized complete block design. These crosses were made in the preceding rice growing season at the Plant Breeding and Genetics Department, The University of Agriculture Peshawar-Pakistan. The genotypes of rice used in the study are shown in Table 1. The rice F_1 crosses and parents were planted in a plot of two rows having length of 3 m, while 30 cm distance was kept among rows and 15 cm among plants. Nursery of the rice hybrids and parents was raised in the end of May and then rice seedlings were shifted into the already well prepared field after one month. The Traits spikelets panicle^{-1}, grains panicle^{-1}, grain length, grain width, 1000-grain weight and grain yield were studied.

Statistical analysis

Analysis of variance technique (ANOVA) was used for data analysis (Steel and Torrie, 1980) while least significant difference (LSD) test was used for means separation. Genotypic (V_g) and phenotypic (V_p) variances, genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV) and broad sense heritability (h^2_{bs}) were computed as given by Singh and Chaudhary (1985);

$$V_g = [MSG - MSE/r]$$
$$V_p = V_g + V_e$$
$$V_e = MSE$$
$$PCV = [\sqrt{Vp}/X] \times 100$$
$$GCV = [\sqrt{V_g}/X] \times 100$$
$$h^2_{bs} = V_g/Ve$$

where;

MSG: Genotype mean square, V_p: Phenotypic variance, MSE: Error mean square and V_e: Error variance. Burton (1952) categorized PCV and GCV as low when the value is less than 10, moderate when less than 20 and high when the value is greater than 20. According to Johnson et al. (1955) heritability was classified as low when value is less than 30%, moderate (30 – 60%) and high when value is greater than 60%. Mid and better parent (MP and BP) heterosis for each trait were determined as suggested by Sharma and Singh (1978);

$$MP\ heterosis\ (\%) = (F_1\text{-}MP)/MP \times 100$$
$$BP\ heterosis\ (\%) = (F_1\text{-}BP)/BP \times 100$$

MP is the average of parental values for a trait and BP is the best parent value of a trait. To determine the significant effects of heterosis both for mid and better parent T-test was used (Wynne et al., 1970);

$$t\text{-}value\ for\ MP\ heterosis = F_1 - MP/\sqrt{(3/8\ EMS)}$$
$$t\text{-}value\ for\ BP\ heterosis = F_1 - BP/\sqrt{(1/2\ EMS)}$$

Results and Discussion

Spikelets panicle^{-1}

Significant differences (P≤0.01) were observed among the rice parents and F_1 crosses for this trait (Table 2) as revealed by the analysis of variance. Mean data (Table 3) of the parental genotypes varied between 109.9 and 238.1 for spikelets panicle^{-1}. Kashmir-Bas showed the lowest number of spikelets panicle^{-1} (109.9) while the parent IR-8 showed the highest value (238.1) for this trait. Among the F_1 hybrids, spikelets panicle^{-1} varied from 187.1 to 270.0. F_1 hybrid Dokri-Bas/DR-92 gave minimum spikelets panicle^{-1} (187.1) while

Dokri-Bas/Bas-6129 displayed maximum number of spikelets panicle^{-1} (270.0) (Table 3). Bagheri and Jelodar (2010) also observed highly significant differences for spikelets panicle^{-1} in a study comprising 7 parental genotypes and their 12 F_1 hybrids which is in agreement with our results. Moderate PCV (19.0), GCV (14.7) and heritability (59.9%) values were observed, respectively (Table 4). Bisne et al. (2009) and Pandey et al. (2012) have also displayed PCV, GCV and heritability moderate values for this trait. Mid parent heterosis values among the F_1 crosses varied between -9.11 and 35.7%. Eight F_1 hybrids showed significant positive mid parent heterosis. F_1 hybrid DR-92/DR-83 manifested maximum mid-parent heterosis value (35.7%). Better parent heterosis among F_1 hybrids ranged from -13.4 and 32.3%. Three F_1 hybrids DR-92/DR-83 (32.3%), Dokri-Bas/Bas-6129 (20.1%) and Dokri-Bas/DR-83 (17.8%) showed significant positive better parent heterosis (Table 5). Our findings are in conformity with Bagheri and Jelodar (2010) and Soni and Sharma (2011) who also reported significant positive heterosis for spikelets panicle^{-1}.

Table 1: *List of the parents and their F_1 hybrids used in the study.*

Rice genotypes		
	Parents	Hybrids
1	NIAB-IR-9	NIAB-IR-9/IR-8
2	Dokri-Bas	Dokri-Bas/DR-92
3	Bas-2008	Dokri-Bas/DR-83
4	DR-92	Dokri-Bas/Sugdesi
5	Bas-6129	Dokri-Bas/Pakhal
6	IR-8	Dokri-Bas/Bas-6129
7	DR-83	Bas-2008/Kashmir-Bas
8	Sugdesi	Bas-2008/TN-1
9	Pakhal	Bas-2008/Dilrosh
10	Kashmir-Bas	DR-92/Dokri-Bas
11	TN-1	DR-92/DR-83
12	Dilrosh	Bas-6129/Bas-370
13	Bas-370	Bas-6129/Dokri-Bas
14	Shahdab-31	IR-8/NIAB-IR-9
15		IR-8/Sugdesi
16		IR-8/Shahdab-31

Grains per panicle

The rice genotypes (parents and F_1 hybrids) manifested significant differences (P≤0.01) for grains panicle^{-1} (Table 2). The parental genotypes confirmed a range of mean values from 95.3 to 214.4 (Table 3). The rice parent Kashmir-Bas produced maximum (214.4) grains panicle^{-1} while minimum value (95.3) of this trait was manifested for Bas-6129. Mean values for hybrids varied from 160.6 to 232.7. F_1 cross combinations Dokri-Bas/DR-92 and DR-92/DR-83 displayed minimum (160.6) and maximum (232.7) for this trait, respectively (Table 3). For this trait, Rahimi et al. (2010) provided similar results and exemplified significant effects of the rice genotypes included six parents and 15 F_1 hybrids. Moderate PCV, GCV and heritability values of 19.1, 13.5 and 50.0% were observed (Table 4) which are in line with the results of Subbaiah et al. (2011) and Bhadru et al. (2012). Heterosis of mid parent for this trait varied between 7.66 and 48.3%. Five F_1 cross combinations displayed significant positive mid parent heterosis. F_1 hybrid DR-92/DR-83 manifested highest positive mid parent heterosis (48.3%). Better parent heterosis values among F_1 cross combinations ranged from -20.3 to 45.1%. Only two hybrids, DR-92/DR-83 (45.1%) and Dokri-Bas/DR-83 (24.9%) showed significant positive better parent heterosis (Table 5). The findings of this study are in accordance to the research results of Islam et al. (2010) who exhibited significant values of heterosis of better parent for this trait in various hybrid combinations.

Table 2: *Mean square values for morphological traits of 30 rice genotypes.*

Mean squares			
Traits	Replications	Genotypes	Error
Spikelets panicle^{-1}	1251.3	2622.0**	656.8
Grains panicle^{-1}	546.0	1804.5**	598.8
Grain length	0.67	0.95**	0.22
Grain width	0.03	0.05**	0.01
1000-grain weight	4.21	16.0**	2.11
Grain yield m^{-2}	0.03	0.06**	0.01
Degrees of freedom	1	29	29

***: Significant at 1% probability level.*

Grain length

For grain length, the rice parents and their F_1 cross combinations revealed significant differences (P≤0.01) (Table 2). Among the parental genotypes, this trait varied from 7.11 to 10.9 mm while among F_1 hybrids the value of the trait ranged between 8.92 and 9.82 mm (Table 3). Among the parents, TN-1 displayed minimum value (7.11 mm) while NIAB-IR-9 showed maximum value (10.9 mm) for

Table 3: *Mean values for spikelets panicle^{-1}, grains panicle^{-1}, grain length, grain width, 1000-grain weight and grain yield of 30 rice genotypes.*

Rice genotypes	Spikelets panicle^{-1}	Grains panicle^{-1}	Grain length (mm)	Grain width (mm)	1000-grain weight (g)	Grain yield m^{-2} (kg)
NIAB-IR-9/IR-8	210.1	168.1	9.40	3.15	29.2	0.56
Dokri-Bas/DR-92	187.1	160.6	9.33	2.90	25.6	0.53
Dokri-Bas/DR-83	254.5	222.2	8.97	2.98	22.8	0.44
Dokri-Bas/Sugdesi	225.6	193.2	9.27	3.38	27.2	0.53
Dokri-Bas/Pakhal	214.4	188.6	9.76	2.98	26.4	0.44
Dokri-Bas/Bas-6129	270.0	211.0	9.13	2.85	17.9	0.53
Bas-2008/Kashmir-Bas	212.4	187.8	9.50	3.10	31.5	0.39
Bas-2008/TN-1	205.1	186.9	9.52	3.00	29.0	0.21
Bas-2008/Dilrosh	211.1	180.8	8.92	3.11	27.8	0.25
DR-92/Dokri-Bas	249.3	207.9	9.74	2.97	27.5	0.62
DR-92/DR-83	258.9	232.7	9.76	3.06	28.6	0.47
Bas-6129/Bas-370	257.1	217.9	9.20	2.87	22.5	0.31
Bas-6129/Dokri-Bas	239.5	212.4	9.16	2.91	25.2	0.83
IR-8/NIAB-IR-9	253.7	210.3	9.58	2.93	28.0	0.64
IR-8/Sugdesi	264.0	197.1	9.06	3.10	22.8	0.58
IR-8/Shadab-31	233.2	188.9	9.82	3.13	29.1	0.81
NIAB-IR-9	170.9	153.3	10.9	2.79	24.4	0.53
Dokri-Bas	216.0	177.9	8.85	2.94	24.8	0.33
Bas-2008	216.5	182.5	9.94	3.00	26.5	0.45
DR-92	195.7	153.4	9.98	2.88	28.2	0.44
Bas-6129	224.8	214.4	8.50	2.98	26.0	0.56
IR-8	238.1	210.8	9.37	3.10	30.9	0.97
DR-83	185.9	160.4	9.28	3.08	25.3	0.33
Sugdesi	214.7	178.8	9.17	3.19	28.5	0.58
Pakhal	185.3	156.8	9.61	3.06	27.9	0.44
Kashmir-Bas	109.9	95.3	9.96	2.97	23.1	0.44
TN-1	171.5	151.0	7.11	3.39	26.2	0.69
Dilrosh	181.0	154.5	8.26	3.44	27.3	0.31
Bas-370	167.3	141.2	10.3	2.90	24.4	0.42
Shahdab-31	173.4	155.9	10.2	2.96	24.2	0.47
LSD(0.05)	52.4	50.0	0.97	0.21	2.97	0.20

grain length while among the F_1 hybrids, Bas-2008/Dilrosh displayed the smallest grains (8.92 mm) and IR-8/Shahdab-31 gave the longest grains (9.82 mm) (Table 3). Subbaiah et al. (2011) studied 16 parental genotypes and 48 hybrid combinations of rice and observed significant differences for grain length. The rice genotypes depicted low PCV and GCV values of 8.16% and 6.41% while high heritability value of 61.8% for grain length (Table 4). Babu et al. (2012) also showed similar results. They observed low PCV (9.80%) and GCV (9.63%) and high heritability (96.5%) values for this trait. Significantly positive mid parent heterosis value of 11.7% (Bas-2008/TN-1) was observed for grain length. Most of the F_1 genotypes confirmed better parent heterosis in negative for the trait in study (Table 5). The possible reason for this could be the diversity of parental genotypes used to derive F_1 hybrids. Reddy et al. (2012) in their study recorded significantly positive mid parent heterosis for this trait.

Grain width

Rice parents and their F_1 cross combinations gave highly significant values (P≤0.01) for grain width

(Table 2). Means values among the rice parents for grain width ranged from 2.79 to 3.44 mm (Table 3). Parental genotype NIAB-IR-9 showed minimum grain width (2.79 mm) while Dilrosh displayed maximum grain width (3.44 mm). The value of the trait among F_1 crosses ranged between 2.85 and 3.38 mm. F_1 hybrid Dokri-Bas/Bas-6129 showed the lowest value for grain width (2.85 mm) while Dokri-Bas/Sugdesi displayed the highest value (3.38 mm) for this trait (Table 3). Rahimi et al. (2010) and Subbaiah et al. (2011) also exhibited highly significant values for grain width. Low PCV (5.73%), GCV (4.58%) and high heritability (63.9%) was observed for grain width (Table 4), which is in accordance to the research findings of Subbaiah et al. (2011) and Babu et al. (2012). Heterosis of mid parent for this trait ranged between -6.10 to 10.3%. Two F_1 hybrids Dokri-Bas/Sugdesi (10.3%) and NIAB-IR-9/IR-8 (6.96%) displayed significant positive mid parent heterosis while one F_1 cross combination Dokri-Bas/Sugdesi produced significant positive heterosis (5.96%) of better parent (Table 5). For grain width, Reddy et al. (2012) also provided same results of positive significant heterosis for mid and better parent.

Table 4: *Phenotypic (V_p), genotypic (V_g) and environmental variances (V_e), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) and broad sense heritability (h^2bs) for different traits of 30 rice genotypes.*

Traits	Vp	Vg	Ve	PCV	GCV	h^2bs
Spikelets panicle^{-1}	1639.9	981.6	658.3	19.0	14.7	59.9
Grains panicle^{-1}	1200.2	599.5	600.7	19.1	13.5	50.0
Grain length	0.59	0.36	0.22	8.16	6.41	61.8
Grain width	0.03	0.02	0.01	5.73	4.58	63.9
1000-grain weight	9.08	6.95	2.13	11.5	10.0	76.6
Grain yield m^{-2}	0.03	0.02	0.01	36.4	31.0	72.6

1000-grain weight

For 1000-grain weight, the parents and their F_1 hybrids displayed significant ($P \leq 0.01$) results (Table 2). The range of mean values for 1000-grain weight among the parents was 23.1 to 30.9 g while among the F_1 hybrids the value of the trait ranged between 17.9 and 31.5 g (Table 3). Parental genotype Kashmir-Bas showed minimum grain weight (23.1 g) while IR-8 displayed maximum grain weight (30.9 g). F_1 cross Dokri-Bas/Bas-6129 gave the lowest 1000-grain weight (17.9 g) while Bas-2008/Kashmir-Bas produced the highest grain weight (31.5 g) (Table 3). Soni and Sharma (2011) assessed 9 rice parents and 27 F_1 cross combinations and observed significant effects for 1000-grain weight. The genotypes showed moderate PCV (11.5%), GCV (10.0%) and high heritability (76.6%) for 1000-grain weight (Table 4). Bahadru et al. (2012) also reported moderate PCV (10.7%), moderate GCV (10.50%) and high heritability (96.0%), respectively for this trait. Four hybrids Bas-2008/Kashmir-Bas (26.9%), IR-8/Sugdesi (23.4%), Bas-2008/TN-1 and DR-92/DR-83 had given significant heterosis in positive of mid parent for 1000-grain weight. Two F_1 hybrid combinations Bas-2008/Kashmir-Bas (18.9%) and Bas-2008/TN-1 (9.5%) manifested significant positive better parent heterosis (Table 5). The present research study findings are in agreement with the results of Soni and Sharma (2011) who also observed positive and significant heterosis of mid and better parent for 1000-grain weight.

Grain yield

Mean squares of rice genotypes displayed significant differences for grain yield (Table 2). The rice parents displayed mean values of the range 0.31 to 0.97 kg m^{-2} for this trait (Table 3). Parental genotype Dilrosh had the lowest grain yield (0.31 kg m^{-2}) while IR-8 gave the highest yield (0.97 kg m^{-2}). Among the F_1 hybrids, mean values varied from 0.21 to 0.83 kg m^{-2}. F_1 hybrid Bas-2008/TN-1 displayed minimum yield (0.21 kg m^{-2}) while Bas-6129/Dokri-Bas produced the highest yield (0.83 kg m^{-2}) (Table 3). Rahimi et al. (2010); Bagheri and Jelodar (2010) and Subbaiah et al. (2011) also exhibited highly significant values of the rice genotypes for grain yield. Rice genotypes showed high PCV (36.4%), GCV (31.0%) and heritability (72.6%) value (Table 4). Bhadru et al. (2012) reported high PCV (24.5%), GCV (23.0%) and heritability (88%) for grain yield. F_1 cross combinations Bas-6129/Dokri-Bas (87.5%), DR-92/Dokri-Bas (59.3%) and Dokri-Bas/DR-92 (35.7%) displayed significant positive mid parent heterosis. Two F_1 hybrids Bas-6129/Dokri-Bas (50.0%) and DR-92/Dokri-Bas (39.4%) showed significant positive better parent heterosis (Table 5). Saleem et al. (2008) and Islam et al. (2010) also recorded positive heterosis for grain yield in various hybrid combinations, which are in accordance with our findings.

Table 5: *Mid parent heterosis (MPH) and better parent heterosis (BPH) for spikelets panicle^{-1}, grains panicle^{-1}, grain length, grain width, 1000-grain weight and grain yield among F_1 hybrids of rice.*

F_1 hybrid combinations	Spikelets panicle^{-1}		Grains panicle^{-1}		Grain length		Grain width		1000-grain weight		Grain yield	
	MPH (%)	BPH (%)	MPH (%)	BPH (%)	MPH (%)	BPH (%)	MPH (%)	BPH (%)	MPH (%)	BPH (%)	MPH (%)	BPH (%)
NIAB-IR-9/IR-8	2.74	-11.8	-7.66	-20.3*	-7.21*	-13.7**	6.96**	1.61	5.56	-5.50	-25.9**	-42.9**
Dokri-Bas/DR-92	-9.11	-13.4	-3.05	-9.72	-0.90	-6.51	-0.34	-1.36	-3.26	-9.14*	35.7*	18.8
Dokri-Bas/DR-83	26.7**	17.8*	31.4**	24.9*	-1.05	-3.34	-1.00	-3.25	-8.70*	-9.53*	33.3	33.3
Dokri-Bas/Sugdesi	4.76	4.44	8.33	8.05	2.89	1.09	10.3**	5.96*	2.20	-4.47	15.2	-9.52
Dokri-Bas/Pakhal	6.85	-0.74	12.7	6.01	5.74	1.56	-0.67	-2.61	0.42	-5.13	14.3	0.00
Dokri-Bas/Bas-6129	22.5**	20.1*	7.57	-1.59	5.24	3.16	-3.72	-4.36	-29.5**	-31.1**	18.8	-5.00
Bas-2008/Kashmir-Bas	30.2**	-1.89	35.2**	2.90	-4.52	-4.62	3.85	3.33	26.9**	18.9**	-13.0	-13.6
Bas-2008/TN-1	5.72	-5.27	12.1	2.41	11.7**	-4.23	-6.10**	-11.5**	10.2**	9.53*	-64.1**	-70.4**
Bas-2008/Dilrosh	6.21	-2.49	7.30	-0.93	-1.98	-10.3**	-3.42	-9.59**	3.41	1.94	-33.8*	-44.4**
DR-92/Dokri-Bas	21.1**	15.4	25.5**	16.9	3.45	-2.40	2.06	1.02	3.72	-2.59	59.3**	39.4*
DR-92/DR-83	35.7**	32.3**	48.3**	45.1**	1.35	-2.20	2.68	-0.65	6.85*	1.22	21.4	6.25
Bas-6129/Bas-370	31.1**	14.4	22.6**	1.63	-2.23	-10.9**	-2.38	-3.69	-10.5**	-13.2**	-37.1**	-45.0**
Bas-6129/Dokri-Bas	8.67	6.54	8.28	-0.93	5.59	3.50	-1.69	-2.35	-0.54	-2.79	87.5**	50.0**
IR-8/NIAB-IR-9	24.1**	6.55	15.5	-0.24	-5.43	-12.0**	-0.51	-5.48*	1.13	-9.47**	-14.8	-34.3**
IR-8/Sugdesi	16.6**	10.9	1.18	-6.50	-2.27	-3.31	-1.43	-2.82	-23.4**	-26.3**	-25.0**	-40.0**
IR-8/Shadab-31	13.3	-2.06	3.03	-10.4	0.31	-3.82	3.30	0.97	5.86	-5.67	11.5	-17.1*

***, *: Significant at 1% and 5% levels of probability, respectively.*

Conclusions

The rice parents and F_1 hybrids displayed significant differences for all the studied traits. Among the parental genotypes, Bas-6129 and Bas-370 exhibited highest values for grains panicle^{-1} while IR-8 produced maximum spikelets panicle^{-1}, 1000-grain weight and grain yield. F_1 hybrids Dokri-Bas/Bas-6129, DR-92/DR-83, Bas-6129/Dokri-Bas and Bas-2008/Kashmir-Bas gave the highest spikelets panicle^{-1}, grains panicle^{-1}, grain yield and 1000-grain weight, respectively. All of the traits exhibited high broad sense heritability except grains panicle^{-1}. DR-92/DR-83 exhibited the highest positive heterosis of both mid and better parent for spikelets panicle^{-1} and grains panicle^{-1} while Bas-2008/Kashmir-Bas and Bas-6129/Dokri-Bas displayed maximum values of positive heterosis of mid and better parent for 1000-grain weight and grain yield. Parental genotypes IR-8, Bas-6129 and Bas-370 are suggested for onward use in rice hybridization programs. F_1 hybrids DR-92/DR-83, Bas-6129/Dokri-Bas and Bas-2008/Kashmir-Bas are recommended for proceeding to advanced generations to derive desirable recombinant inbred lines and cultivars.

Author's Contribution

MI collected, analyzed data and wrote the manuscript. SMAS provided technical assistance in data collection, its analysis and manuscript preparation. AZ and MAR helped in data collection and compilation.

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