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Development of high yielding short duration Boro rice through Aus x Boro crossing

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ABSTRACT

This research aimed to develop high-yielding, short-duration Boro rice by examining F_2 populations of inter-varietal crosses of *Oryza sativa* at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. Key objectives included evaluating mean performance, general and specific combining abilities (GCA and SCA), and residual heterosis. Combining ability analysis indicated significant GCA and SCA effects across most traits, suggesting the involvement of both additive and non-additive gene actions. The cross BR21 x BR24 showed the highest, desirable SCA effect for days to maturity, indicating its potential as the best specific combiner for earliness. For yield and yield-contributing traits, BR26 x BRRI Dhan29 displayed the most favorable SCA effects, emerging as a strong candidate for yield improvement, followed by BRRI Dhan28 x BRRI Dhan29, BR26 x BRRI Dhan36, and BR24 x BR26. These combinations also demonstrated heterosis, making them promising for further evaluation of earliness and yield performance. Mean performance results highlighted BR21 x BRRI Dhan36 and BR24 x BRRI Dhan36 as requiring the shortest time to flowering and maturity while maintaining reasonable yields, suggesting their potential for developing short-duration, high-yielding rice varieties.

Introduction

The demand for rice is constantly rising in Bangladesh with nearly 2.3 million people being added each year to its population of about 150 million. Rice production increases must be achieved at a faster rate than in most other countries, while the rice growing land is not expanding. In addition, Bangladesh is faced with production constraints such as drought, lack of irrigation facilities, flooding and salinity of soils, coupled with fluctuating commercial rice prices.

Primary constraints to achieving food security are the low yield per unit area and negligible scope for expansion of the area of land for cultivation. Hence, increase in intensity of cultivation and in yields per unit area are the only available options to meet future food needs to feed an ever increasing population. In Bangladesh most of the farmers are growing more than one crop on the same land during one year of production system. Within this concept there are many possible cropping patterns. With the availability of short duration HYV of Boro rice farmers will be able to grow any third crop between T. Aman and Boro rice (L. Hassan & M.A Quddus, 2014).

In Bangladesh, most of the farmers are growing many varieties of boro rice annually in many regions of Bangladesh. Those varieties required long growth duration. So farmers need more irrigation, labor and chemical costing. Due to the lacking in the availability of short duration HYV of Boro rice farmers are reluctant to grow any third crop in between T. Aman and Bororice.So, it is needed to be reduced the duration of boro rice and developing high yielding rice.

As, people of northern region produce huge amount of potato during October to January. So, short duration rice cultivation in boro season (just after harvest of potato in late January or early February) as additional rice production technology may be a blessing to northern Bangladesh.

For the improvement of rice through breeding program i.e., development of high- yielding varieties with short duration boro rice need to select parent first. But parent selection is so much difficult task because yield is a polygenic character resulting from the interaction of yield contributing characters influenced by environmental fluctuations. Selection is the important aspect in a crop improvement program, but it is difficult to make improvement through direct selection on the basis of phenotypic performance only. The value of selected progeny would largely depend upon the relative contribution of heritable and non-heritable component. In case of hybrid breeding program selection of the parent on the basis of phenotypic performance alone is not sound position since

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phenotypically superior line may yield poor recombination in the segregating generations. Therefore, the parents should be selected or chosen based on their genetic value for any plant breeding program.

Aus rice takes minimum days to maturity. On the other hand boro rice gives maximum yield among all rice. Considering these two features, F_1generation was produced by crossing aus and boro rice for combining short duration and high yielding character. BR 21, BR 24 and BR 26 were selected as aus rice. BRRI Dhan 28, BRRI Dhan 29 and BRRI Dhan 36 were selected as boro rice. Present study was carried out on F_2 generation for estimating the mean performance of crosses and parental material, GCA, SCA and also estimating the F_2heterosis over parent.

Diallel analysis provides an effective means of obtaining rapid information about the genetic features of the homogygous lines. Selection of parental lines in terms of their ability to combine in hybrid combinations and subsequently use them for developing pure line or hybrid varieties depend upon their nature of combining ability. The study of combining ability also offers scope in partitioning the genetic component of characters into additive and non-additive components. General combining ability (GCA) measures the additive and specific combining ability (SCA) measures the non- additive genetic variations. The breeding methods for exploiting these two types of genetic variations are different from each other. The parent with high GCA could be used for developing inbred variety while crosses showing high SCA could be used for developing hybrid varieties. So the present study has been undertaken to select short duration materials of Boro rice and to select higher yielding materials of Boro rice.

Materials and Methods

Experimental site

The study was carried out in Sher-E-Bangla Agricultural University (SAU) research field during Rabi season, 2011. The experimental field belongs to the Agro-ecological zone of "The ModhupurTract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b).

Area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). During the study period (October, 2011 to March, 2012) the minimun air temperature was between 11.1 to 18.0 ^{0}C with lowest in the January, 2012 and highest in October, 2011. The maximum air temperature was between 29.0 to 34.8 ^{0}C in January, 2012 and October, 2011 respectively. Relative humidity was ranged 55% in Februry, 2012 to 79% in December, 2011. The average rainfall was highest (227mm) in October, 2011 and lowest in January and February, 2012. In march the rainfall was 45mm. Wherease no rainfall was recorded in November and December, 2011.

Characteristics of soil

Soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.0- 6.6 and had organic matter 0.84%, Total N 0.46%, available phosphorous 21 ppm and exchangeable K 0.41 meq / 100 g soil(SRDI). Experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field.

Parent plant and crossing

A set of three Aus cultivars namely BR-21, BR-24 & BR-26 and a set of three Boro cultivars namely BRRI dhan-28, BRRI dhan-29 and BRRI dhan-36 were used as parents for a half diallel cross. All possible combination crosses (excluding reciprocals) were done in a half diallel mating design to produce 15 F_1 seeds. The study was undertaken with the F_2 materials of the crosses to evaluate the performance. The crosses were 36×29; 36×28; 36×26; 36×24; 36×21; 29×28; 29×26; 29×24; 29×21; 28×26; 28×24; 28×21; 26×24; 26×21 and 24×21.

Experimental design

The experimental design used was a randomized complete block design (RCBD) with three replications. Each replicate or block contained 21 experimental units or plots (6 parents and 15 F_2 materials). Each plot is consisted 1m width and 4m length.

Cultivation practices

The seeds of genotypes were sown in nursery beds on December 2nd of 2011.The seedlings were transplanted on January 15th of 2012 25 cm a part. Routine cultural practices, similar to those used in commercial production of rice, were done as needed. Harvesting was started when 80% of seeds in each plant reached at maturity.

Collection of Data

Data were recorded from 20 randomly selected plants per plot. Among the characters studied days to 50% flowering and plant height were recorded from the field and the remaining characters were recorded in the field laboratory after harvesting. Data were collected for the Plant height, Days to 50% flowering, Number of tillers/plant, Number of effective tillers/plant, Number of effective tillers/plant, Panicle length, Panicle weight, Number of primary branches/panicle, Number of secondary branches/panicle, Number of filled grain of main tiller, Total number of spikelet/panicle, Days to maturity, Fresh weight of 100 grains, Dry weight of 100 grains and Yield/plant.

Analysis of data

Statistical analyses were done to calculate the Analysis of variances, mean performance, combining ability analysis and heterosis estimation (Griffing, 1956).

Results and Discussion

Genetic variability

The mean squares due to genotypes for all the traits under present study were highly significant different as showed in the ANOVA. The results indicated significant differences among 21 genotypes of the present diallel study, which was necessary for further analysis (Table 1). Genotypes have been partitioned into parents (P) and crosses (F_2) items. Significant mean squares due to parents and crosses were observed for most of the characters except for panicle length, panicle weight, No. of primary branches per plant, No. of secondary branches per plant, filled grains of main tiller and panicle per plant. Which indicating the presence of adequate genetic variability and the genetic inference could be calculated (Barar and Sukhija, 1977).

Plant height

Data in Table 2 showed that the cross (BR21×BR24) had the tallest plant (109.1 cm) followed by BR21×BRRI dhan 26 (105.5 cm), BR24×BRRI dhan 29 (104.9 cm), BR21×BR26 (104.1 cm), BR24 (103.6 cm), BR24×BRRI dhan 28 (101.8 cm), BR21×BRRI dhan 28 (101.4 cm), BR21 (99.93 cm), BRRI dhan 28 (99.67 cm), BR24×BRRI dhan 36 (98.98 cm), BR21×BRRI dhan 29 (98,96 cm), BR24×BR26 (98.88 cm), BR26 (98.30 cm), BRRI dhan 29 (96.57 cm), BR26×BRRI dhan 36 (96.15 cm), BRRI dhan 28×BRRI dhan 29 (95.48 cm), BRRI dhan 28×BRRI dhan 36 (93.78 cm), BR26×BRRI dhan 29 (93.92 cm), BR26×BRRI dhan 28 (90.84 cm) and BRRI dhan 29×BRRI dhan 36 (89.90 cm), while the parental cultivar BRRI dhan 36 had the shortest (81.43 cm) one.

Days to 50% flowering

Concerning days to 50% flowering, the recorded 50% flowering days ranged from 90 (90.67) to 94 (94.33). The cross BR26×BRRI dhan 36 required maximum days to 50% flowering (94.33), while the parental materials required minimum days (90.67) to 50% flowering. The cross BR21×BR24 required minimum days to flowering (91.33) followed by BR21×BRRI dhan 28 (91.66). These crosses are significantly different from each other while the other crosses are statistically similar.

Number of tillers/plant

Regarding number of tillers per plant, the parental material BR26 gave the highest number of tillers per plant (28.77), while the cross BR21×BR24 gave the lowest (16.83) one. The cross combination BRRI dhan 28×BRRI dhan 29 had maximum number of tiller (26.95) followed by BRRI dhan 29×BRRI dhan 36 (26.65), BR26×BRRI dhan 36 (25.27) and BR26×BRRI dhan 29 (25.18). These combination performances are statistically similar while the other crosses had statistically lower number of tiller per plant than the discussed materials.

Table 1: The analysis of variance of the half diallel mating design for various traits in rice

SOV	df	Plant Height (cm)	Days to 50% Flowering	Total no of tiller/Plant	No. of effective tiller/plant	Panicle length (cm)	Panicle weight (gm)	No. of primary branch/panicle	No. of secondary branch/panicle
Rep	2	51.013	10.619	16.57	18.165	6.111	0.187	0.017	3.508
Genotype	20	116.213 **	3.267	30.01	24.76 **	2.565	0.064	0.223	4.301
GCA	5	296.625 **	8.933 **	73.079 **	72.503 **	1.511	0.076	0.088	7.802
(SCA	14	56.076 *	1.378	15.654	8.847	2.917	0.061	0.268	3.133
Error	40	26.672	2.286	13.968	7.846	2.267	0.073	0.217	4.554

SOV	df	Filled grain of main tiller	Total no. of spikelet/ panicle	Fress weight of 100 grain(gm)	Dry weight of 100 grain(gm)	Yield/plant(fresh weight in gm)	Yield/plant(dry weight in gm)	Days to maturity.
Rep	2	257.954	289.011	0.001	8.956	105.725	23.111 *	140.182
Genotype	20	146.701	166.365	0.002 **	0.002 **	199.811 **	100.144 **	252.531 **
GCA	5	249.479	298.68	7.665	7.44	535.944 **	328.311 **	658.903 **
SCA	14	112.441	122.259	0.003 **	0.002 **	87.766	24.089 **	117.074 *
Error	40	153.238	136.33	4.49	6.036	46.482	4.761	58.101

** indicates significant at the 0.01 level; * indicates significant at the 0.05 level

Table 2: Mean performance of parents and their F_2 generations

Variety	PH(cm)	D5F	TTP	ETP	PL (cm)	PW (gm)	PBP	SBP
F2 generation								
21×24	109.13	91.333	16.833	15.017	23.507	3.117	10.4	28.467
21×26	104.12	92	18.967	16.9	23.247	3.067	10.383	28.567
21×28	101.43	91.667	22.75	20.85	23.283	3.293	10.283	28.933
21×29	98.96	92	23.817	21.983	23.677	3.053	10.617	27.05
21×36	105.48	92	21.433	19.75	23.567	3.127	10.333	29.067
24×26	98.88	91.667	17.717	15.987	23.27	3.21	10.967	29.8
24×28	101.78	92.667	20.583	18.767	23.47	2.97	10.267	27.833
24×29	104.93	93.667	22.25	20.117	23.287	3.073	10.15	28.317
24×36	98.98	92	23.876	22.533	22.493	3.05	10.533	28.133
26×28	90.84	91.333	22.167	20.7	22.793	3.09	9.967	26.733
26×29	93.20	92.667	25.183	23.333	23.46	2.847	10.35	26.05
26×36	96.15	94.333	25.267	23.15	23.907	3.433	10.733	29.583
28×29	95.48	92.333	26.95	24.683	24.003	3.297	10.3	28.617
28×36	93.78	92.667	22.433	20.533	27.067	3.31	10.483	28.1
29×36	89.90	93.667	26.65	24.8	23.393	3.07	9.817	26.583
Parents								
21	99.93	90.667	21.033	19	23.083	2.863	10.7	26.767
24	103.57	93	17.8	15.8	23.137	3.003	10.7	28
26	98.30	91.333	28.767	19.867	23.14	3.017	10.567	27.6
28	99.67	90.667	20.267	23.933	23.117	3.107	10.733	28.167
29	96.57	93.667	23.8	21.967	22.32	2.96	10.667	24.933
36	81.43	93.667	23.867	21.833	22.943	3.173	10.433	28.767
LSD Value	8.69	2.699	6.186	4.758	2.579	0.4602	0.7515	3.497

PH= Plant Height, D5F= Days to 50% Flowering, TTP= Total Tiller/ Plant, ETP= Effective Tiller/Plant, PL= Panicle Length, PW= Panicle Weight, PBP= Primary Branches/panicle, SBP= Secondary Branches/Panicle

Variety	GMT	SP	FW of 100 Grain(gm)	DW of 100 Grain(gm)	Yield /Plant(FW in gm)	Yield /Plant (DW in gm)	DM
F2 generation							
21×24	151.35	159.333	2.223	2.077	33.587	32.603	143.667
21×26	151.7	160.55	2.23	2.087	40.73	37.243	142
21×28	164.217	173.433	2.26	2.113	49.107	45.217	143.333
21×29	145.717	156.567	2.213	2.057	57.193	52.673	146
21×36	154.75	163.9	2.277	2.133	51.563	46.897	141
24×26	156.367	166.917	2.253	2.12	42.92	39.713	147.667
24×28	146.85	153.983	2.233	2.107	47.647	43.283	143
24×29	147.667	155.333	2.243	2.107	57.167	52.39	149.667

24×36	150.167	158.85	2.257	2.113	59.173	54.067	144
26×28	152.567	159.9	2.267	2.127	48.597	44.67	141.667
26×29	142.757	150.067	2.257	2.117	68.11	62.837	158
26×36	170.6	179.117	2.253	2.093	62.647	57.437	145.667
28×29	161.433	169.5	2.26	2.123	68.097	62.507	152.333
28×36	160.733	170.517	2.233	2.107	52.333	48.28	146.667
29×36	152.433	161.617	2.243	2.103	61.53	56.58	149.333
Parents							
21	145.167	153.867	2.203	2.083	44.837	41.507	141
24	152.167	160.4	2.183	2.073	58.58	51.953	144.667
26	156.967	164.7	2.21	2.093	51.86	47.253	143.333
28	160.1	167.7	2.21	2.077	55.347	50.497	142.333
29	151.773	153.067	2.227	2.097	64.207	58.403	164
36	160.433	168.133	2.163	2.043	62.637	57.107	148.333
LSD Value	20.73	19.75	0.05211	0.05211	12.98	11.57	3.911

GMT= No of filled grain of main tiller, SP= Total number of spikelet/panicle, FW= Fresh weight, DW= Dry weight, DM= Days to maturity

Number of effective tillers/plant

Regarding the number of effective tillers per plant, the cross BRRI dhan 29×BRRI dhan 36 gave highest number of effective tillers per plant (24.80) followed by BRRI dhan 28×BRRI dhan 29 (24.68), BR26×BRRI dhan 29 (23.33) and BR26×BRRI dhan 36 (23.15) which are statistically similar in performance for number of effective tiller per plant. The cross BR21×BR24 gave the lowest (15.02) number of effective tiller per plant.

Panicle length

Data regarding panicle length show that the cross BRRI dhan 28×BRRI dhan 36 had tallest panicle (27.07 cm), while the parental material BRRI dhan29 had the shortest (22.32 cm) one. All the other parental materials and crosses along with the shortest one had panicle length statistically similar to each other and differing from the tallest one (Table 2).

Panicle weight

Data regarding panicle weight show that the cross BR26×BRRI dhan 36 had maximum panicle weight (3.433 g), while the cross BR26×BRRI dhan 29 had the minimum (2.847 g) one. These two crosses are solely different statistically.

Number of primary branches/panicle

Regarding the number of primary branches per panicle, the cross BR24×BR26 gave highest number of primary branches per panicle (10.97), while the cross BRRI dhan 29×BRRI dhan 36 gave the lowest number (9.817) of primary branches per panicle.

Number of secondary branches/panicle

Regarding the number of secondary branches per panicle, the cross BR24×BR26 gave highest number of primary branches per panicle (29.80) followed by BR26×BRRI dhan 36 (29.58), BR21×BRRI dhan 36 (29.07), BR21×BRRI dhan 28 (28.93), BRRI dhan 36 (28.77), BRRI dhan 28×BRRI dhan 29 (28.93), BR21×BR26 (28.57), BR21×BR24 (28.47), BR24×BRRI dhan 29 (28.32), BRRI dhan 28 (28.17), BR24×BRRI dhan 36 (28.13), BRRI dhan 28×BRRI dhan 36 (28.10), BR24 (28.00), BR24×BRRI dhan 28 (27.83), BR26 (27.60), BR21×BRRI dhan 29 (27.05), BR21 (26.77), BRRI dhan 26×BRRI dhan 28 (26.73), BRRI dhan 29×BRRI dhan 36 (26.58) and BRRI dhan 26×BRRI dhan 29 (26.05), while the parental material BRRI dhan 29 gave the lowest (24.93) one. BR26×BRRI dhan 36 (29.58) and BR24×BR26 (29.80) gave statistically similar number of secondary branches per panicle.

Number of filled grain of main tiller

Regarding the number of filled grain of main tiller, the cross BR26×BRRI dhan 36 gave highest number of filled grain (170.6), while the cross BR26×BRRI dhan 29 gave the lowest (142.8) one. These two crosses had truly difference by LSD test.

Total number of spikelet/panicle

Regarding total number of spikelet per panicle, the cross BR26×BRRI dhan 36 gave highest number of spikelet per panicle (179.1), while the cross BR26×BRRI dhan 29 gave the lowest (150.1) one. These two crosses had truly difference by LSD test.

Days to maturity

Concerning days to maturity, the recorded days ranged from about 141 to 164. The parental material BRRI dhan 29 required maximum days (164), while the other parental material BR21 required minimum days (141) to maturity. Cross combination BR21×BRRI dhan 36 required minimum days to maturity (141) followed by BR26×BRRI dhan-28 (141.7) which is statistically similar.

Fresh weight and dry weight of 100 grains

Fresh weight of 100 grains was recorded maximum in cross BR21×BRRI dhan 36 (2.133 g), while the parental material BRRI dhan 36 gave minimum (2.043 g) fresh weight of 100 grains. The dry weight also recorded similar to the fresh weight in terms of maximum and minimum value (Table 2).

Yield/plant

Concerning yield in fresh weight and dry weight, the fresh weight yield ranged from 33.59 g/plant to 68.11 g/plant and the dry weight ranged from 32.60 g/plant to 62.84 g/plant. The cross BR26×BRRI dhan 29 had the highest yield both in fresh and dry basis, while the cross BR21×BR24 had the lowest one in both cases.

General and specific combining ability

The half diallel mating design used in this study makes it possible to obtain estimates for the different genetic parameters required for judging further breeding programs, general and specific combining ability effects are of these parameters. Combining ability can play a better role in identifying the precious genotypes; having specific cross combinations, having high usable heterosis and for further selection in segregating generations. The results of analysis of variance and mean squares of the half diallel mating design for all studied traits are shown in table 1. Significant mean squares for GCA and SCA confirm the presence of combining ability.

Plant height

Data presented in Table 1 showed that GCA variation was highly significant, while SCA was significant for plant height. BR24 had the highest positive GCA effects with 4.17 followed by BR21 with 3.94 (Table 3) whereas BRRI dhan-36 had the highest negative GCA effect (-5.04) followed by BRRI dhan-29 (-1.49), BR26 (-0.96) and BRRI dhan-28 (-0.61). As higher negative significant GCA effect is expected for this trait, BRRI dhan-36 was the best general combiner followed by BRRI dhan-29, BR26 and BRRI dhan28. Sharma and Mani (2001) reported UPR 85-71-8-1 as a good general combiner for shorter plant height.

The cross BR26xBRRI dhan28 showed highest negative SCA effect (-5.80) followed by BR26xBRRI dhan29 (-2.56), BR24×BR26 (-2.53), BRRI dhan29×BRRI dhan36 (-1.78) and BR21×BRRI dhan29 (-1.70) (Table 4). Therefore, the cross BR26xBRRI dhan28 was observed to be the best specific combiner for plant height. Singh et al. (1998) observed Basmati370×Dubraj as best specific combiner for plant height in their study.

Table 3: Estimates of parental general combining ability effects for various traits

Parents	Plant Height (cm)	Days to 50% Flowering	Total no of tiller/Plant	N. of effective tiller/plant	Panicle length (cm)	Panicle weight (gm)	No. of primary branch /panicle	No. of secondary branch /panicle	No. of filled grain of main tiller	Total no. of spikelet /panicle	Fress weight of 100 grain (gm)	Dry weight of 100 grain (gm)	Yield/plant (fresh weight in gm)	Yield/plant (dry weight in gm)	Days to maturity
BR21	3.94**	-0.75**	-1.45**	-1.42**	-0.08*	-0.04**	0.04**	0.03**	-2.57**	-1.79**	-0.003**	-0.006**	-6.26**	-3.49**	-7.18**
BR24	4.17**	0.13**	-2.58**	-2.48**	-0.22**	-0.04**	0.07**	0.40**	-2.74**	-2.58**	-0.007**	0.002**	-2.72**	-1.07**	-2.70**
BR26	-0.96**	-0.21**	1.17**	-0.50**	-0.14**	0.01**	0.05**	0.07**	1.16**	1.27**	0.006**	0.006**	-1.41**	-0.53**	-1.57**
BRRI dhan 28	-0.61**	-0.54**	-0.26**	1.20**	0.35**	0.06**	-0.05**	0.15**	3.42**	3.36**	0.005**	0.006**	-0.34*	-1.78**	-0.35
BRRI dhan 29	-1.49**	0.67**	1.87**	1.88**	-0.20**	-0.06**	-0.07**	-1.11**	-3.14**	-4.58**	0.004**	0.002**	7.01**	7.18**	7.65**
BRRI dhan 36	-5.04**	0.71**	1.24**	1.32**	0.28**	0.08**	-0.05**	0.46**	3.87**	4.31**	-0.006**	-0.006**	3.72**	-0.32**	4.15**
SE (gi)	0.96	0.28	0.70	0.52	0.28	0.05	0.09	0.40	2.31	2.18	0.004	0.005	1.27	0.41	1.42
SE (gi-gj)	1.49	0.44	1.08	0.81	0.43	0.08	0.13	0.62	3.57	3.37	0.006	0.007	1.97	0.63	2.20

** indicates Significant at the 0.01 level; * indicates Significant at the 0.05 level

Table 4: Estimates of parental specific combining ability effects for various traits

Crosses	Plant Height (cm)	Days to 50% Flowering	Total no of tiller /Plant	No. of effective tiller/Plant	Panicle length (cm)	Panicle weight (gm)	No. of primary branch / panicle	No. of secondary branch/Panicle
BR21xBR24	2.82**	-0.38**	-1.63**	-1.64**	0.36**	0.09**	-0.16**	0.13
BR21xBR26	2.93**	0.63**	-3.25**	-1.73**	0.02	0.01	-0.15**	0.55**
BR21xBRRI Dhan28	-0.11	0.63**	1.96**	0.52**	-0.43**	0.18**	-0.15**	0.84**
BR21xBRRI Dhan29	-1.70**	-0.25**	0.90**	0.98**	0.51**	0.05**	0.20**	0.22
BR21xBRRI Dhan36	8.38**	-0.29**	-0.85**	-0.71**	-0.08	-0.01	-0.10**	0.67**
BR24xBR26	-2.53**	-0.58**	-3.37**	-1.58**	0.19	0.15**	0.40**	1.42**
BR24xBRRI Dhan28	0.01	0.75**	0.92**	-0.50**	-0.10	-0.16**	-0.21**	-0.62**
BR24xBRRI Dhan29	4.04**	0.54**	0.46	0.17	0.27**	0.06**	-0.30**	1.12**
BR24xBRRI Dhan36	1.64**	-1.17**	2.71**	3.14**	-1.01**	-0.09**	0.06**	-0.63**
BR26xBRRI Dhan28	-5.80**	-0.25**	-1.24**	-0.54**	-0.86**	-0.07**	-0.49**	-1.40**
BR26xBRRI Dhan29	-2.56**	-0.13**	-0.36	1.41**	0.36**	-0.19**	-0.08**	-0.82**
BR26xBRRI Dhan36	3.94**	1.50**	0.36	1.78**	0.33**	0.26**	0.28**	1.15**
BRRI28xBRRI Dhan29	-0.64	-0.13**	2.84**	1.06**	0.42**	0.19**	-0.03	1.67**
BRRI28xBRRI Dhan36	1.22**	0.17**	-1.05**	-2.54**	3.00**	0.07**	0.13**	-0.41**
BRRI29xBRRI Dhan36	-1.78**	-0.04**	1.04**	1.05**	-0.13	-0.05**	-0.51**	-0.67**
SE (±)	2.64	-0.08	1.91	1.43	0.77	0.14	0.24	1.09

Crosses	No. of filled grain of main tiller	Total no. of spikelet/ panicle	Fresh weight of 100 grain (gm)	Dry weight of 100 grain (gm)	Yield /plant (fresh weight in gm)	Yield /plant (dry weight in gm)	Days to maturity
BR21xBR24	2.57**	1.44	-0.002	-0.015**	-8.10**	1.67**	-10.72**
BR21xBR26	-0.98	-1.19	-0.005**	-0.011**	-4.76**	-0.54**	-4.71**
BR21xBRRI Dhan28	9.28**	9.60**	0.024**	0.016**	2.15**	2.04**	2.45**
BR21xBRRI Dhan29	-2.66**	0.67	-0.023**	-0.037**	2.25**	-4.25**	2.54**
BR21xBRRI Dhan36	-0.63	-0.88	0.052**	0.047**	-0.24	-1.75**	0.41
BR24xBR26	3.85**	5.97**	0.022**	0.017**	-5.83**	2.71**	-6.99**
BR24xBRRI Dhan28	-7.92**	-9.07**	0.002	0.004*	-3.33**	-0.71**	-3.48**
BR24xBRRI Dhan29	-0.54	0.22	0.012**	0.009**	-1.58**	-3.00**	-1.97**
BR24xBRRI Dhan36	-5.05**	-5.14**	0.037**	0.023**	3.39**	-1.17**	3.54**
BR26xBRRI Dhan28	-6.11**	-6.99**	0.021**	0.016**	-3.25**	-2.58**	-3.67**
BR26xBRRI Dhan29	-9.34**	-8.88**	0.013**	0.011**	7.56**	4.79**	7.84**
BR26xBRRI Dhan36	11.48**	11.28**	0.018**	-0.005**	5.46**	-0.04	5.88**
BRRI28xBRRI Dhan29	7.07**	8.45**	0.016**	0.018**	6.17**	0.38**	6.61**

BRRI28xBRRI Dhan36	-0.64**	0.59	0.01	0.008**	-4.77**	2.21**	-5.65**
BRRI29xBRRI Dhan36	-2.38**	-0.37	0.008**	0.007**	-3.83**	-4.08**	-4.46**
SE (±)	6.34	5.98	0.011	0.013	3.49	1.12	3.90

** indicates Significant at the 0.01 level; * indicates Significant at the 0.05 level

Days to 50% flowering

A higher negative significant GCA value is expected for this trait. The highest significant and negative GCA effects for days to 50% flowering were found in the parent BR21 (-0.75) followed by BRRI dhan28 (-0.54) and BR26 (-0.21) (Table 3). Rest of the parents showed positive significant GCA effect which is undesirable for this trait.

A higher negative significant SCA value is expected for this trait. The highest negative SCA effect was observed in the cross BR24×BRRI dhan36 with value -1.17 (Table 4). Therefore, the cross BR24xBRRI dhan36 was observed to be the best specific combiner for days to 50% flowering. The crosses Raimunuwa×Poornima and Poornima×Vanprabha were reported best specific combiner for this trait by Singh and Singh (2004).

Number of tillers/plant

Regarding number of tillers per plant, it was found that GCA was highly significant (Table 1).BRRI dhan29 had the highest positive GCA effect (1.87) followed by BRRI dhan36 (1.24) and BR26 (1.17), while other plants had negative GCA effects for number of tillers per plant (Table 3). As higher positive significant GCA effect is expected for this trait, BRRI dhan29 was the best general combiner for tillers per plant. Mahsuri was reported good general combiner for this trait by Singh *et al.* (1998).

The estimates of SCA effects for crosses showed that the cross BRRI dhan28xBRRI Dhan29 had highest positive significant SCA effect (2.84) followed by BR24xBRRI Dhan36 (2.71), BR21xBRRI Dhan28 (1.96), BRRI dhan29xBRRI Dhan36 (1.04), BR24xBRRI Dhan28 (0.92) and BR21xBRRI Dhan29 (0.90), while the other crosses had negative or non-significant values (Table 4). As the higher positive significant SCA effect is desired for this character, BRRI dhan28xBRRI Dhan29 was identified as the best specific combiner.

Number of effective tillers/plant

Regarding number of effective tillers per plant, it was found that GCA was highly significant (Table 1).BRRI dhan29 had the highest positive GCA effect (1.88) followed by BRRI dhan36 (1.32) and BRRI28 (1.20), while other plants had negative GCA effects for number of effective tillers per plant (Table 3). As higher positive significant GCA effect is expected for this trait, BRRI dhan29 was the best general combiner for tillers per plant.

The estimates of SCA effects for crosses showed that the cross BR24xBRRI Dhan36 had highest positive significant SCA effect (3.14) followed by BR26×BRRI dhan29 (1.41), BRRI dhan28xBRRI Dhan29 (1.06), BRRI dhan29xBRRI Dhan36 (1.05), BR21xBRRI Dhan29 (0.98) and BR21xBRRI Dhan28 (1.96), while the other crosses had negative or non-significant values (Table 4). As the higher positive significant SCA effect is desired for this character, BR24xBRRI Dhan36 was identified as the best specific combiner.

Panicle length

The parent BRRI dhan28 (0.35) showed highest positive and significant GCA effect followed by BRRI dhan36 (0.08). Rest of the parents showed significant negative GCA effects which are undesirable for panicle length. Therefore, BRRI dhan28 and BRRI dhan36 is good general combiner for obtaining long panicle. The parent PWR54 was a good general combiner for panicle length reported by Singh *et al.* (1998).

The highest significant positive SCA effect was provided by BRRI dhan28×BRRI dhan36 (3.00) followed by BR21×BRRI dhan29 (0.51), BRRI dhan28×BRRI dhan29 (0.42), BR26×BRRI dhan29 (0.36), BR21×BR24

(0.36), BR26×BRRI dhan36 (0.33) and BR24×BRRI dhan29 (0.27) for this trait. These crosses may be considered as the good specific combiner for panicle length.

Panicle weight

The highest significant positive effect was obtained from the parent BRRI dhan36 (0.08) followed by BRRI dhan28 (0.06) and BR26 (0.01) for panicle weight. Rest of the parents showed significant negative GCA effects which are undesirable for panicle weight. As the positive significant GCA value is expected for this trait, BRRI dhan36, BRRI dhan28 and BR26 were identified as good general combiner for higher panicle weight. Dhakar *et al.* (2006) observed the parents Vikas, Kanak and IR-64 were good general combiner for panicle weight.

The highest significant positive SCA effect for panicle weight was observed in the cross BR26×BRRI dhan36 (0.26). Cross combinations BR21×BR24 (0.09), BR21×BRRI dhan28 (0.18), BR21×BRRI dhan29 (0.05), BR24×BR26 (0.15), BR24×BRRI dhan29 (0.06), BRRI dhan28×BRRI dhan29 (0.19) and BRRI dhan28×BRRI dhan36 (0.07) showed positive significant SCA effects. These crosses therefore may be selected for improve the panicle weight of rice.

Number of primary branches/panicle

The parent BR24 (0.07) possessed the highest positive significant GCA effect for primary branches per panicle followed by BR26 (0.05) and BR21 (0.04). The other parents showed negative significant GCA effects which is undesirable for this trait. Hence BR24 was identified as good combiner for more primary branches per panicle followed by BR26 and BR21.

The highest significant positive SCA effect was found in the cross BR24×BR26 (0.40) for this character followed by BR26×BRRI dhan36 (0.28), BR21×BRRI dhan29 (0.20), BRRI dhan28×BRRI dhan36 (0.13) and BR24×BRRI dhan36 (0.06), while the other crosses had significant negative or non-significant SCA effects. As significant positive SCA effect is desirable for this trait, the cited above crosses were identified as good specific combiners to increase primary branches per panicle.

Number of secondary branches/panicle

The highest positive GCA effect was observed in the parent BRRI dhan36 (0.46) for secondary branches per panicle followed by BR24 (0.40), BRRI dhan28 (0.15), BR26 (0.07) and BR21 (0.03). Therefore, BRRI dhan36 was considered as the best general combiner for obtaining more secondary branches per panicle.

The cross BRRI dhan28×BRRI dhan29 (1.67) exhibited the highest positive significant SCA effect followed byBR24×BR26 (1.42), BR26×BRRI dhan36 (1.15), BR24×BRRI dhan29 (1.12), BR21×BRRI dhan28 (0.84), BR21×BRRI dhan36 (0.67) and BR21×BR26 (0.55). These crosses were found to be good for improving number of secondary branches per panicle. Rest of the crosses showed significant negative or non-significant SCA effects which is undesirable for this trait.

Number of filled grain of main tiller

A higher and positive significant GCA value is expected for this trait. The highest positive significant GCA effect for this character was found in parent BRRI dhan36 (3.87) followed by BRRI dhan28 (3.42) and BR26 (1.16). Rest of the three parents showed negative significant GCA effects which is undesirable for this trait. Therefore, BRRI dhan36 was considered as the best general combiner followed by BRRI dhan28 and BR26 for filled grain of main tiller. Ali *et al*. (1994) reported Basmati370 as the best general combiner for percentage of filled grains.

A higher, positive and significant SCA value is expected for this trait. The highest significant positive SCA effect was found in the cross BR26×BRRI dhan36 (11.48) for filled grains of main tiller followed by BR21×BRRI dhan28 (9.28), BRRI dhan28×BRRI dhan29 (7.07) and BR21×BR24 (2.57). These crosses were found to be good specific combiner for more filled grains on main tiller. Basmati 370×Basmati 385 was reported as best specific combiner for this trait by Ali *et al*. (1994).

Total number of spikelet/panicle

A higher and positive significant GCA value is expected for this trait. The highest positive significant GCA effect for this character was found in parent BRRI dhan36 (4.31) followed by BRRI dhan28 (3.36) and BR26 (1.27). Rest of the three parents showed negative significant GCA effects which is undesirable for this trait. Therefore, BRRI dhan36 was considered as the best general combiner followed by BRRI dhan28 and BR26 for number of spikelet per panicle.

A higher, positive and significant SCA value is expected for this trait. The highest significant positive SCA effect was found in the cross BR26×BRRI dhan36 (11.28) for filled grains of main tiller followed by BR21×BRRI dhan28 (9.60), BRRI dhan28×BRRI dhan29 (8.45) and BR24×BR26 (5.97). These crosses were found to be good specific combiner for more number of spikelet per panicle. Rest of the crosses showed negative significant or non-significant SCA effects which is undesirable for this trait.

Days to maturity

A higher and negative significant GCA value is expected for this trait. The highest negative GCA effect was exhibited by the parent BR21 (-7.18) for days to maturity followed by BR24 (2.70) and BR26 (1.57). The other parents had negative significant or non-significant SCA effects which is undesirable for this trait. Therefore, BR21 was considered as the best general combiner followed by BR24 and BR26 for days to maturity. Sharma and Mani (2001) observed UPR 85-71-8-1 as a good combiner for earliness.

The highest negative SCA effect was observed in the cross BR21×BR24 (-10.72) for earliness followed by BR24×BR26 (-6.99), BRRI dhan28×BRRI dhan36 (-5.65), BR21×BR26 (-4.71), BRRI dhan29×BRRI dhan36 (-4.46), BR26×BRRI dhan28 (-3.67), BR24×BRRI dhan28 (-3.48) and BR24×BRRI dhan29 (-1.97). Rest of the crosses had positive significant SCA effects. Thus, BR21×BR24 was the best combiner for earliness followed by BR24×BR26, BRRI dhan28×BRRI dhan36 BR21×BR26, BRRI dhan29×BRRI dhan36, BR26×BRRI dhan28, BR24×BRRI dhan28 and BR24×BRRI dhan29.

Fresh weight and dry weight of 100 grains

A higher significant positive GCA value was expected for these traits. The highest significant GCA effect was observed in the parent BR26 (0.006) for fresh weight of 100 grains followed by BRRI dhan28 (0.005) and BRRI dhan29 (0.004). The other parents showed negative significant GCA effects which is undesirable for this trait. The highest significant GCA effects were observed in the parent BR26 and BRRI dhan28 (0.006) followed by BRRI dhan29 (0.002) and the other parents showed negative significant effects for dry weight of 100 grains. Therefore, the parent BR26 was the best general combiner for both dry and fresh weight of 100 grains.

A higher significant positive SCA value was expected for fresh and dry weight of 100 grains. The highest significant SCA effect was observed in the cross BR21×BRRI dhan36 (0.052) followed by BR24×BRRI dhan36 (0.037), BR21×BRRI dhan28 (0.024), BR24×BR26 (0.022), BR26×BRRI dhan28 (0.021), BR26×BRRI dhan36 (0.018), BRRI dhan28×BRRI dhan29 (0.016), BR26×BRRI dhan29 (0.013) and BR24×BRRI dhan29 (0.012) and the other crosses showed negative significant or non-significant SCA effects for the trait, fresh weight of 100 grains. The highest significant SCA effect was obtained from the cross BR21×BRRI dhan36 (0.047) followed by BR24×BRRI dhan36 (0.023), BRRI dhan28×BRRI dhan29 (0.018), BR24×BR26 (0.017), BRBR26×BRRI dhan28 (0.016), BR21×BRRI dhan28 (0.016), BR26×BRRI dhan29 (0.011), BR24×BRRI dhan29 (0.009), BRRI dhan28×BRRI dhan36 (0.008), BRRI dhan29×BRRI dhan36 (0.007), BR26×BRRI dhan36 (0.005) and BR24×BRRI dhan28 (0.004) for dry weight of 100 grain. Therefore, the cross BR21×BRRI dhan36 was the best specific combiner for both dry and fresh weight of 100 grains.

Yield/plant

The highest significant and positive GCA effect was found in the parent BRRI dhan29 (7.01) followed by BRRI dhan36 (3.72) for yield per plant in fresh weight. The other parents were obtained negative significant GCA effects which is undesirable for this trait. On the other hand, the highest significant positive GCA effect was provided by the parent BRRI dhan29 (7.18) for dry weight yield per plant, while the other parents possessed negative significant GCA effects which is undesirable. Therefore, BRRI dhan29 was the best combiner for yield per plant for both dry and fresh weight. Borgohain *et al*. (1998) observed DWR2, DWR1, DWR5 were the best general combiners for grain yield. The parent Raimunuwa, JR 353 and RWR 3-45 were good general combiners for grain yield per plant found by Singh and Singh (2004).

A higher and positive significant SCA value was expected for these characters. The highest significant positive SCA effects was observed by the cross BR26×BRRI dhan29 (7.56) followed by BRRI dhan28×BRRI dhan29 (6.17), BR26×BRRI dhan36 (5.46), BR24×BRRI dhan36 (3.39), BR21×BRRI dhan29 (2.25) and BR21×BRRI dhan28 (2.15) for fresh weight of yield per plant. The other crosses had negative significant or non-significant SCA effects for this trait. The highest significant positive SCA effects was observed by the cross BR26×BRRI dhan29 (4.79) followed by BR24×BR26 (2.71), BRRI dhan28×BRRI dhan36 (2.21), BR21×BRRI dhan28 (2.04), BR21×BR24 (1.67) and BRRI dhan28×BRRI dhan29 (0.38) for dry weight of yield per plant. The other crosses had negative significant or non-significant SCA effects for this trait. Therefore, the crosses BR26×BRRI dhan29 was considered the best combiner for yield per plant both in fresh and dry weight. The cross combinations DWR1×DWR2, DWR2×DWR4, DWR3×DWR6 and DWR5×DWR6 was the four best specific combiner for developing variety with higher yield reported by Borgohain *et al*. (1998). Singh and Singh (2004) observed the crosses Raimunuwa × Poornima and Poornima× Vanparabha were the best specific combiners for crop yield.

Heterosis

The amount of heterosis value could be expressed as the percentage deviation of F_2 generation versus the average of mid parent (MP) or the mean of the standard check parent (SP) (Figure 1).

Plant height

Heterosis value was obtained from the MP and SP for plant height is presented in (Table 5). The results showed that significant heterosis over standard parents for plant height in three crosses from 15 crosses.

Days to 50% flowering

Concerning days to 50% flowering, three crosses out of 15 crosses showed significant with positive values over standard parent.

Number of tillers/plant

Regarding number of tillers per plant, only 4 crosses had significant or highly significant values of heterosis over mid parent, while 14 crosses had significant or highly significant values of heterosis over standard parent.

Number of effective tillers/plant

Regarding number of effective tillers per plant, only 7 crosses had significant or highly significant values of heterosis over mid parent, while all the crosses except one had significant or highly significant values of heterosis over standard parents.

Figure 1: Photograph showing grain of parent and F_2 materials

Table 5: F_2 Heterosis (%) over mid parent and check variety in different characters in rice

Variety	PH (cm)		D5F		TTP		ETP		PL (cm)		PW (gm)	
	MPH	SH	MPH	SH	MPH	SH	MPH	SH	MPH	SH	MPH	SH
21*24	7.26	9.50*	-0.55	0.73	-13.31	-16.94*	-13.70*	-37.25*	1.72	1.69	6.27*	0.32
21*26	5.05	4.46	1.10	1.47	-23.83*	-6.41*	-13.04*	-29.39*	0.59	0.56	4.32*	-1.29*
21*28	1.64	1.77	1.10	1.10	10.17	12.25*	-2.87	-12.88*	0.79	0.72	10.32*	5.99*
21*29	0.72	-0.71	-0.18	1.47	6.25	17.52*	7.32	-8.15*	4.30	2.42**	4.86*	-1.74*
21*36	16.32	5.84	-0.18	1.47	-4.53	5.75*	-3.26	-17.48*	2.41	1.95	3.61*	0.64*
24*26	-2.03	-0.79	-0.54	1.10	-23.91*	-12.58*	-10.35**	-33.20*	0.57	0.66	6.64*	3.32*
24*28	0.16	2.12	0.91	2.21	8.14	1.56*	-5.53	-21.59*	1.48	1.53	-2.78*	-4.41*
24*29	4.86	5.28	0.36	3.31*	6.97	9.78*	6.53	-15.94*	2.46	0.74	3.07*	-1.09*
24*36	7.01	-0.69	-1.43	1.47	14.60**	17.81*	19.75*	-5.85*	-2.37	-2.70*	-1.23*	-1.83*
26*28	-8.22	-8.85*	0.37	0.73	-9.59	9.37*	-5.48	-13.51*	-1.45	-1.40	0.91	-0.55*
26*29	-4.35	-6.49	0.18	2.21	-4.19	24.26*	11.55**	-2.51	3.21	1.48	-4.73*	-8.37*
26*36	6.99	-3.53	1.98	4.04*	-3.99	24.67*	11.03**	-3.27	3.76	3.42*	10.92*	10.49*
28*29	-2.68	-4.20	0.18	1.84	22.31*	32.97*	7.55	3.13	5.65**	3.83*	8.69*	6.12*
28*36	3.57	-5.90	0.54	2.21	1.66	10.69*	-10.27	-14.21*	17.53*	17.09*	5.41*	6.53*
29*36	1.01	-9.80*	0.00	3.31*	11.82	31.49*	13.24*	3.62	3.36	1.19	0.11	-1.19*

Variety	PBP		SPP		GMT		SP		FW of 100 grain (gm)		DW of 100 grain (gm)	
	MPH	SH	MPH	SH	MPH	SH	MPH	SH	MPH	SH	MPH	SH
21×24	-2.80*	-3.10*	3.96	1.07	1.80	-5.47	1.40	-4.99	1.37*	0.59*	-0.05	0.00
21×26	-2.36*	-3.26*	5.09	1.42	0.42	-5.25	0.80	-4.26	1.07*	0.90*	-0.05	0.48*
21×28	-4.05*	-4.19*	5.34	2.72	7.59	2.57	7.87	3.42	2.42*	2.26*	1.59*	1.73*
21×29	-0.62	-1.08*	4.64	-3.97*	-1.85	-8.98	2.02	-6.64	-0.09	0.14*	-1.58*	-0.96*
21×36	-2.21*	-3.73*	4.68	3.20*	1.28	-3.34	1.80	-2.27	4.31*	3.03*	3.39*	2.70*
24×26	3.14*	2.18*	7.19	5.80*	1.16	-2.33	2.69	-0.47	2.57*	1.95*	1.78*	2.07*
24×28	-4.19*	-4.34*	-0.89	-1.19	-5.95	-8.28	-6.14	-8.18	1.66*	1.04*	1.54*	1.44*
24×29	-4.99*	-5.43*	6.99	0.53	-2.83	-7.77	-0.89	-7.37	1.72*	1.49*	1.06*	1.44*
24×36	-0.32	-1.86*	-0.88	-0.12	-3.92	-6.20	-3.30	-5.28	3.87*	2.13*	2.67*	1.73*
26×28	-6.41*	-7.14*	-4.13	-5.09*	-3.76	-4.71	-3.79	-4.65	2.58*	2.58*	2.01*	2.41*
26×29	-2.51*	-3.57*	-0.82	-7.52*	-7.52	-10.83	-5.55	-10.51	1.74*	2.13*	1.05*	1.93*
26×36	2.22*	0.00	4.97	5.03*	7.50	6.56	7.63	6.81	3.04*	1.95*	1.21*	0.77*
28×29	-3.74*	-4.03*	7.79	1.60	3.52	0.83	5.68	1.07	1.87*	2.26*	1.72*	2.21*
28×36	-0.94	-2.33*	-1.29	-0.24	0.29	0.40	1.55	1.68	2.13*	1.04*	2.28*	1.44*
29×36	-6.95*	-8.53*	-0.99	-5.62*	-2.35	-4.79	0.63	-3.63	2.19*	1.49*	1.59*	1.25*

** indicates Significant at the 0.01 level; * indicates Significant at the 0.05 level

Variety	Yield/plant (FW in gm)		Yield/ Plant	(DW in gm)	Days to maturity	
	MPH	SH	MPH	SH	MPH	SH
21×24	-35.05**	-39.32*	-30.23*	-35.44*	0.58	0.94
21×26	-15.76	-26.41*	-16.08	-26.25*	-0.12	-0.23
21×28	-1.97	-11.27**	-1.71	-10.46**	1.18	0.70
21×29	4.90	3.34	5.44	4.31	-4.26	2.58
21×36	-4.05	-6.84	-4.89	-7.13	-2.53	-0.94
24×26	-22.27	-22.45*	-19.94	-21.36*	2.55	3.75**
24×28	-16.36	-13.91*	-15.50	-14.29*	-0.35	0.47
24×29	-6.88	3.29	-5.05	3.75	-3.02	5.15*
24×36	-2.37	6.91	-0.85	7.07	-1.71	1.17
26×28	-9.34	-12.20**	-8.60	-11.54**	-0.82	-0.47
26×29	17.36	23.06*	18.95	24.44*	2.82	11.01*
26×36	9.43	13.19*	10.07	13.74*	-0.11	2.34
28×29	13.92	23.04*	14.80	23.78*	-0.54	7.03*
28×36	-11.29	-5.45	-10.26	-4.39	0.92	3.04
29×36	-2.98	11.17**	-2.03	12.05*	-4.38	4.92*

** indicates Significant at the 0.01 level ; * indicates Significant at the 0.05 level

Panicle length

Heterosis value was obtained from the MP and SP for panicle length is presented in table 5 The results showed that significant or highly significant with positive values of heterosis over mid parents for panicle length in two crosses from 15 crosses, while significant values of heterosis over standard parents in only four crosses out of 15.

Panicle weight

Concerning panicle weight, 13 crosses showed significant values of heterosis over mid parent, while 14 crosses showed significant values of heterosis over standard parent.

Number of primary branches/panicle

Regarding number of primary branches per panicle, 12 crosses had significant values of heterosis over mid parents, while all the crosses except one had significant values of heterosis over standard parent.

Number of secondary branches/panicle

Regarding number of secondary branches per panicle, only seven crosses had significant or highly significant values of heterosis over standard parent.

Number of filled grain of main tiller

Regarding number of filled grain of main tiller, no crosses showed significant values of heterosis over mid parents and standard parent also.

Total number of spikelet/panicle

Concerning total number of spikelet per panicle, no crosses showed significant values of heterosis over mid parents and standard parent also.

Days to maturity

Regarding days to maturity, only five crosses had significant or highly significant positive values of heterosis based on standard parent.

Fresh weight and dry weight of 100 grains

Regarding the weight of 100 grains, 14 crosses and all the crosses had significant positive values of heterosis over mid parents and standard parent, respectively in case of fresh weight. On the other hand, 13 and 14 crosses had significant values of heterosis over mid parents and standard parents, respectively for dry weight.

Yield/plant

Regarding yield in fresh weight, only the cross BR21×BR24 had highly significant negative values over mid parent, while ten crosses had significant or highly significant values over standard parent. Similar scenario had observed in case of yield in dry weight.

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