Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.5154

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (6):** 1000-1009 (2017)

International Journal of Pure & Applied Bioscience

Research Article

OPEN ACCESS

Heterosis studies for yield and yield related traits over seasons in boro rice

Kumari Priyanka[*] and H. K. Jaiswal

Department of Genetics and Plant Breeding, Institute of Agricultural Sciences,
Banaras Hindu University, Varanasi – 221 005, Uttar Pradesh (India)

*Corresponding Author E-mail: kpriyanka.choudhary@gmail.com

Received: 6.07.2017 | Revised: 11.08.2017 | Accepted: 14.08.2017

ABSTRACT

Thirty six crosses generated in diallel fashion from nine boro rice parental lines were evaluated to study the heterosis for yield and various yield related traits in rice (Oryza sativa L.) over three seasons i.e. Boro-2014, Kharif-2015 and Boro-2015. The findings suggested that the magnitude of heterosis differed from trait to trait and cross to cross over seasons. For yield per plant, standard heterosis ranged from -57.07% (HUR 36 x MTU 1010) to 34.60% (Jaya x Gautam) in boro-2014, -50.05% (HUR 36 x Gautam) to 39.66% (Krishna Hamsa x Gautam) in boro-2015 and -30.57% (IR 8 x IR 36) to 30.82% (IR 64 x Jaya) in kharif-2015. Jaya x Krishna Hamsa showed consistently significant standard heterosis over the three seasons i.e. 24.47% in boro-2014, 24.14% in boro-2015 and 28.50% in kharif-2015. Theses crosses may further be tested on larger scale for commercial exploitation.

Key words: *Boro rice, Heterobeltiosis, Standard heterosis, Yield.*

INTRODUCTION

Rice is an important food crop cultivated around the world. As the world population is continuously increasing and is expected to reach eight billion by 2030, there is a need to increase rice production by 50% in order to meet the demand[6] ,To obtain high yield is the major objective of rice breeding programmes. F_1 hybrids can be exploited commercially if we know the heterotic potential of a particular cross. The success of hybrid rice breeding programme depends on the magnitude of heterosis and choice of parent materials. Estimates obtained in one season may be biased due to several factors, so the study was conducted over three seasons to observe the traits exhibiting consistent performance over environments. Keeping in view above mentioned facts, better parent heterosis and standard heterosis for yield and yield related traits over seasons was worked out.

MATERIALS AND METHOD

The present study was carried out in three seasons i.e. boro-2014, boro-2015 and kharif-2015 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (UP). Thirty six crosses along with their nine parents (IR 8, IR 36, IR 64, HUR 36, HUR 105, MTU 1010, Jaya, Krishna Hamsa and Gautam) generated from 9 x 9 diallel crosss (excluding reciprocals) were grown in Randomized Block Design in three replications.

Cite this article: Priyanka, K. and Jaiswal H. K., Heterosis studies for yield and yield related traits over seasons in boro rice, *Int. J. Pure App. Biosci.* **5(6):** 1000-1009 (2017). doi: http://dx.doi.org/10.18782/2320-7051.5154

The recommended agricultural practices were followed to raise a good crop. Data were recorded on days to 50% flowering, days to maturity, plant height, effective tillers per plant, main panicle length, flag leaf length, flag leaf width, grains per panicle, 100 seed weight, yield per plant and chlorophyll content. Better parent heterosis and standard parent heterosis were estimated as per given formula the standard checks were Gautam (Boro check) and NDR-359 (Kharif check).

$$\text{Heterobeltiosis (BPH) \%} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

$$\text{Standard Heterosis (SH) \%} = \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$$

Where,

F_1 =Mean value of the F_1 cross

$\overline{BP}$ =Mean value of better parent of the particular cross

$\overline{SC}$ =Mean value of standard check

The significance of different types of heterosis was evaluated by the estimates of critical differences for various traits at 5% and 1% levels of significance.

RESULTS AND DISCUSSIONS

Analysis of variance revealed significant differences among the seasons and genotypes for most of the yield traits over seasons (boro-2014, boro-2015 and kharif-2015). Season x Genotype interaction was found significant for all the traits (Table 1). The estimates of better parent heterosis and standard heterosis of 36 crosses obtained from 9 x 9 diallel mating design excluding reciprocals are presented in Table 2.

For days to 50% flowering, the standard heterosis ranged from -5.44% (MTU 1010 x Krishna Hamsa) to 14.29% (HUR 105 x MTU 1010) in boro-2014, -9.76% (IR 64 x HUR 105) to 20.32 % (HUR 36 x HUR 105) in boro-2015 and -16.49% (Jaya x Krishna Hamsa) to 17.89% (HUR 36 x HUR 105) in kharif-2015. The standard heterosis in both negative and positive direction for days to 50% flowering has been reported by Tiwari *et al*[15]. Priyanka *et al.*[11] and Waza *et al.*[20], Negative heterosis for days to 50% flowering is important as earliness is a desirable trait in case of rice. Negative heterosis for days to 50% flowering was also reported by Malini *et al.*[9] ,Sravan *et al*.[14] and Veeresha *et al*.[18], However, positive standard heterosis was reported by Bisne *et al*.[3] and Malrvizhi *et al*.[8], Among top five best performing crosses, Jaya x Krishna Hamsa showed standard heterosis in all the three seasons in negative direction. More crosses showed negative standard heterosis in kharif season in comparison to boro season. Out of 36 crosses, 14 showed significant negative better parent heterosis in boro-2014, 20 in boro-2015 and 8 in kharif-2015 for days to maturity. Negative heterosis for early maturity is desirable. Kumar *et al*. reported -5.34% to 2.80% heterobeltiosis. However, positive heterosis for the trait was also reported by Khoyumthem *et al*.[5], Among top five best performing crosses, none of the cross showed consistent performance over the season for the trait.

For plant height, out of 36 crosses, 12 showed significant negative heterosis over better parent, 17 crosses showed significant negative standard heterosis over standard check Gautam in boro-2014. In boro-2015, 14 crosses showed significant negative heterosis over their better parent and 23 crosses showed significant negative standard heterosis over check Gautam. In kharif-2015, 19 crosses showed significant negative heterobeltiosis and 30 crosses showed significant negative standard heterosis over the check NDR-359. Negative heterosis for plant height is preferable in case of rice. Negative heterosis for plant height was also reported by Faiz *et al.*[4], and Bagheri[2], However, positive heterosis for the trait was also reported by Saleem *et al.*[12], Heterosis in both negative and positive direction for the trait has been reported by Priyanka *et al.* [11], Sravan *et al.*[14] and Waza *et al.* [20], Among the top five performing crosses, IR 8 x Krishna Hamsa and MTU 1010 x Gautam showed consistent performance over the three seasons.

In boro-2014, very few crosses showed significant positive standard heterosis for effective tillers/plant, whereas none of the crosses showed significant positive standard heterosis in boro-2015. However, in kharif-2015, 19 crosses out of 36 showed significant positive standard heterosis for the trait. Significant positive standard heterosis is desirable for the trait as it directly contributes towards yield. Positive heterosis for effective tillers per plant was also reported by Anand and Singh[1], and Veeresha *et al.*[18], The magnitude of better parent heterosis was more than standard heterosis in boro-2014, suggesting the performance of better parents in the crosses were better than the check. In contrast, magnitude of standard heterosis was more than better parent heterosis in boro-2015 and kharif-2015. None of the top performing crosses showed consistent performance for the trait.

Out of 36 crosses, 9 crosses showed significant positive standard heterosis in boro-2014, 13 crosses in boro-2015 and 8 crosses in kharif-2015 for panicle length. Most of the crosses showed non-significant positive heterosis for the trait. Significant positive heterosis for panicle length is desirable for yield improvement. Significant positive standard heterosis for the trait was also reported by Anand *et al.*[1], Vanaja and Babu[16], Khoyumthem *et al*.[5], whereas, significant positive heterobeltiosis was reported by Narasimman *et al*.[10], Bisne *et al*.[3], and Saravanan[13], The five crosses which recorded high panicle length in boro-2014 and boro-2015 showed significant positive heterobeltiosis for the trait, whereas in kharif-2015, only one cross showed significant heterobeltiosis. However, all the five crosses showed significant positive standard heterosis over the three seasons. Two crosses i.e. MTU 1010 x Jaya and HUR 105 x Gautam, among the top five crosses, showed significant standard heterosis for the trait over season.

In case of flag leaf length, out of 36, 3 crosses in boro-2014, 7 crosses in boro-2015 and 11 crosses in kharif-2015 showed significant positive heterobeltiosis. Out of 36 crosses, 8 crosses in boro-2014, 8 crosses in boro-2015 and 6 crosses in kharif-2015 showed significant positive standard heterosis. Significant positive heterosis is desirable for flag leaf length. None of the five top performing crosses showed consistent standard heterosis in all the three seasons. For flag leaf width, most of the crosses showed non-significant heterosis for the trait in both negative and positive direction. However, significant positive heterosis is desirable for the trait. For flag leaf width, most of the top performer showed non-significant better parent heterosis over the seasons. The extent of better parent heterosis was relatively higher in kharif season. For chlorophyll content, 9 crosses in boro-2014, 9 crosses in boro-2015 and 15 crosses in kharif-2015 showed significant positive heterobeltiosis. Positive standard heterosis was shown by 10 crosses in kharif-2015 and none of the crosses showed standard heterosis for the trait in boro seasons.

The standard heterosis ranged from -48.40% (IR 8 x Gautam) to 61.87% (IR 36 x MTU 1010) in boro-2014, -44.04% (HUR 36 x MTU 1010) to 13.25% (HUR 105 x Gautam) in boro-2015 and -29.74% (IR 8 x Gautam) to 5.04% (HUR 36 x Krishna Hamsa) in kharif-2015 for grains per panicle. Tiwari *et al.*[15], reported -33.56% to 12.08% standard heterosis for the trait. Similar findings were reported by Priyanka *et al*. [11], Few crosses in boro seasons and none of the crosses in kharif-2015 showed significant positive standard heterosis for the trait. Positive and significant heterosis is desirable for grains per panicle as it directly contributes towards yield. Singificant positive standard heterosis for the trait was reported by Anand and singh[1], and Vanaja and Babu[16], For 100 seed weight, positive and significant heterobeltiosis for the trait was shown by 22 crosses in boro-2014, 23 crosses in boro-2015 and only 16 crosses in kharif-2015 out of 36 crosses. The number of crosses showing standard heterosis over the check was more in boro seasons as compare to kharif. Significant positive heterosis is desirable for the trait as it directly contributes towards yield. Positive heterosis for 1000 seed weight was also reported by Anand and Singh[1], Vanaja *et al*.[17], and Bisne *et al*[3].

For yield per plant, better parent heterosis ranged from -56.37% (HUR 36 x MTU 1010) to 34.60% (Jaya x Krishna Hamsa) in boro-2014, -50.05% (HUR 36 x Gautam) to 49.08% (Krishna Hamsa x Gautam) in boro-2015 and -23.46% (HUR 36 x MTU 1010) to 33.90% (IR 36 x MTU 1010) in kharif-2015. Saleem *et al.*[12], reported -6.97% to 66.38% heterobeltiosis for the trait. Among the top five performing crosses only Jaya x Krishna Hamsa showed consistent significant standard heterosis over the three seasons. The standard heterosis ranged from -57.07% (HUR 36 x MTU 1010) to 34.60% (Jaya x Gautam) in boro-2014, -50.05% (HUR 36 x Gautam) to 39.66% (Krishna Hamsa x Gautam) in boro-2015 and -30.57% (IR 8 x IR 36) to 30.82% (IR 64 x Jaya) in kharif-2015. Anand and Singh[1], reported -91.16% to111.28% and Malini *et al.*[9], reported -73.70% to 129.16 % standard heterosis for the trait. In boro-2014, out of 36 only 5 crosses showed significant positive heterobeltiosis and standard heterosis. In boro-2015, 8 crosses showed significant positive heterobeltiosis and standard heterosis, whereas in kharif-2015, 12 crosses showed heterobeltiosis and 11 crosses showed standard heterosis. Significant positive heterosis is desirable for the trait. Positive standard heterosis was also reported by Bisne *et al.*[3], and Venkatesan *et al*[19].

Table 1: ANOVA of 9×9 diallel (9 parents + 36 crosses) for yield and yield related traits in boro rice

SV	DF	Season	DTF	DTM	PH	ET/P	PL	FL	FW	G/P	100SW	Y/P	CC
Replication	2	B-2014	4.82	2.23	0.01	0.05	0.28	3.53	0.01	160.02*	0.00	2.62	0.00
		B-2015	1.79	1.61	0.70	1.27	0.41	1.45	0.02	10.56	0.00	5.86	0.30
		K-2015	0.96	2.69	3.00*	0.34	2.93	1.49	0.00	37.39	0.00	0.54	0.20
Treatments	44	B-2014	263.83***	256.39***	243.00***	11.63***	18.00***	240.03***	0.07***	2765.23***	0.36***	121.92***	38.86***
		B-2015	314.84***	331.49***	304.15***	6.98***	17.17***	194.09***	0.07***	1635.81***	0.51***	172.01***	41.17***
		K-2015	249.73***	229.38***	236.02***	12.65***	21.60***	164.99***	0.09***	1463.99***	0.31***	47.99***	45.92***
Parents	8	B-2014	206.83***	190.58***	344.82***	6.79***	10.44***	198.63***	0.08***	2723.67***	0.49***	18.06**	71.04***
		B-2015	193.93***	199.50***	518.69***	4.98***	5.13**	115.11***	0.03*	2419.68***	0.52***	13.96*	65.95***
		K-2015	285.23***	281.73***	223.37***	4.55**	15.24***	283.31***	0.09***	4243.45***	0.49***	6.67	66.87***
Crosses	35	B-2014	274.10***	265.11***	226.08***	13.02***	20.18***	219.87***	0.07***	2643.79***	0.31***	147.33***	27.03***
		B-2015	334.10***	342.01***	238.89***	7.53***	20.40***	215.95***	0.08***	1224.94***	0.46***	211.06***	34.43***
		K-2015	246.47***	219.91***	233.46***	13.10***	21.28***	140.69***	0.09***	466.59***	0.23***	56.56***	29.93***
Parent Vs. Crosses	1	B-2014	360.15***	477.90***	20.93***	1.86	2.44	1276.66***	0.02	7348.27***	1.21***	63.17**	195.60***
		B-2015	608.02***	1019.56***	871.73***	3.68	0.08	61.00***	0.08*	9745.25***	2.19***	69.55***	78.74***
		K-2015	80.12***	142.09***	426.84***	61.68***	83.70	68.77***	0.34***	14137.35***	1.75***	78.66***	437.94***
Error	88	B-2014	1.56	1.38	0.78	1.61	1.80	2.75	0.02	47.56	0.00	6.01	0.97
		B-2015	1.41	1.61	1.33	1.32	1.67	1.49	0.01	38.28	0.00	5.92	0.84
		K-2015	1.56	1.53	0.67	1.29	1.50	2.32	0.01	39.22	0.00	4.13	0.98

*p≤0.05; **p≤0.01;***p≤0.001; SV-Source of variation; DF – Degrees of freedom; DTF – Days to 50% flowering; DTM – Days to maturity; PH- Plant height; ET/P – Effective tillers/plant; PL- Panicle length; FL – Flag leaf length; FW- Flag leaf width; G/P- Grains/panicle; 100SW- 100 seed weight; Y/P- Yield/plant; CC- Chlorophyll content; B-2014 – Boro 2014; B-2015 – Boro 2015; K-2015 – Kharif 2015.

Table 2: Estimates of heterosis over better parent (BPH) and standard check (SH) of the diallel set of crosses in boro rice for yield and yield related traits

	Days to 50% flowering						Days to maturity						Plant Height					
	Boro- 2014		Boro-2015		Kharif-2015		Boro- 2014		Boro-2015		Kharif-2015		Boro- 2014		Boro-2015		Kharif-2015	
Cross	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH
P1 x P2	6.41**	12.93**	7.04**	11.52**	13.64**	5.26**	5.95**	11.36**	4.02**	8.38**	7.56**	2.40	-1.70*	-12.17**	-2.63*	-15.05**	-13.26**	-21.45**
P1 x P3	1.99**	4.76**	-1.66*	1.25	-6.45**	-8.42**	0.00	2.84**	-2.13**	0.80	-2.19*	-4.80**	-3.98**	-14.20**	-3.77**	-16.04**	-6.54**	-22.23**
P1 x P4	-1.28	4.76**	-3.52**	0.51	-12.08**	-8.07**	-1.08*	3.98**	-4.02**	0.00	-10.77**	-7.20**	6.07**	-5.23**	0.05	-12.71**	-10.88**	-16.90**
P1 x P5	-0.85	5.22**	0.00	4.18**	-5.37**	-1.05	0.00	5.11**	-1.72**	2.40**	-4.36**	-0.53	13.25**	1.20	3.16*	-10.00**	-6.80**	-13.09**
P1 x P6	0.47	-2.27**	-2.72**	-3.65**	2.89*	-12.63**	0.00	-1.14*	-2.63**	-3.79**	1.80	-9.60**	14.19**	2.03*	21.02**	5.59**	-2.36**	-8.95**
P1 x P7	3.63**	9.98**	6.81**	11.28**	5.15**	7.37**	4.32**	9.66**	4.41**	8.78**	3.15**	4.80**	22.18**	9.17**	21.94**	6.39**	6.40**	-0.78

P1 x P8	-3.97**	-1.36	-1.69*	-0.22	-2.30	-10.53**	-2.21**	0.57	-2.37**	-1.20	-0.85	-7.20**	-2.68**	-13.04**	-7.77**	-19.53**	-8.80**	-24.65**
P1 x P9	-3.40**	-3.40**	-2.44**	-2.42**	0.81	-12.63**	-2.08**	-2.08**	-2.00**	-2.00**	0.00	-10.40**	12.27**	0.32	8.29**	-5.52**	5.52**	-6.60**
P2 x P3	7.07**	9.98**	7.60**	10.79**	15.53**	7.02**	6.26**	9.28**	5.43**	8.58**	8.12**	2.93**	0.34	-4.63**	3.69**	-4.18**	1.26	-15.74**
P2 x P4	4.38**	13.61**	4.67**	15.19**	25.38**	16.14**	4.21**	12.50**	4.07**	12.18**	17.09**	11.47**	12.57**	12.49**	2.84**	5.24**	8.86**	-1.42
P2 x P5	-2.71**	5.90**	-6.00**	3.45**	4.92**	-2.81*	-2.11**	5.68**	-5.00**	2.40**	1.68	-3.20**	9.58**	9.49**	4.61**	5.16**	6.63**	-3.43**
P2 x P6	-1.40	-4.08**	-4.44**	-5.36**	-0.41	-15.44**	-2.11**	-3.22**	-4.44**	-5.59**	-0.90	-12.00**	-7.22**	-11.85**	-12.05**	-17.00**	-12.60**	-20.85**
P2 x P7	-13.96**	-6.35**	-16.67**	-8.29**	-2.27	-9.47**	-11.58**	-4.55**	-13.89**	-7.19**	-3.08**	-7.73**	-8.90**	-8.97**	-16.87**	-14.93**	-8.36**	-17.01**
P2 x P8	3.97**	6.80**	5.54**	7.12**	6.13**	-2.81*	2.21**	5.11**	3.75**	4.99**	3.42**	-3.20**	11.96**	6.38**	-1.15	-4.52**	15.85**	-4.29**
P2 x P9	5.44**	5.44**	1.96**	1.98**	9.72**	-4.91**	5.11**	5.11**	1.60*	1.60	7.74**	-3.47**	-7.39**	-7.46**	-17.42**	-17.42**	1.64	-10.03**
P3 x P4	10.60**	13.61**	0.48	3.45**	10.39**	8.07**	3.68**	6.63**	-2.33*	0.60	9.32**	6.40**	-1.47	-6.34**	1.45	-6.24**	-2.91**	-19.21**
P3 x P5	3.09**	5.90**	-12.35**	-9.76**	8.96**	6.67**	-6.63**	-3.98**	-11.05**	-8.38**	4.93**	2.13	-1.89*	-6.74**	-8.29**	-15.24**	-10.17**	-25.25**
P3 x P6	-1.40	-4.08**	-2.96**	-3.89**	2.89*	-12.63**	2.11**	0.95	-2.42**	-3.59**	1.80	-9.60**	4.62**	-0.60	2.61*	-5.17**	-5.51**	-21.37**
P3 x P7	-8.83**	-6.35**	-11.40**	-8.78**	-6.45**	-8.42**	-5.89**	-3.22**	-10.47**	-7.78**	-4.66**	-7.20**	-5.25**	-9.93**	-3.52**	-10.84**	-14.16**	-28.57**
P3 x P8	3.97**	6.80**	-8.92**	-7.56**	-2.30	-10.53**	-5.34**	-2.65**	-7.69**	-6.59**	-3.42**	-9.60**	0.50	-4.51**	-2.24	-9.65**	2.75**	-15.11**
P3 x P9	5.44**	5.44**	-2.44**	-2.42**	2.02	-11.58**	0.95	0.95	-6.59**	-6.59**	0.89	-9.60**	3.23**	-1.87*	-4.64**	-11.87**	-6.14**	-21.89**
P4 x P5	2.88**	13.38**	8.37**	20.32**	6.67**	17.89**	1.39**	10.61**	5.71**	14.57**	4.44**	12.80**	21.89**	25.25**	16.98**	17.61**	19.76**	11.67**
P4 x P6	3.73**	0.91	1.23	0.27	6.61**	-9.47**	3.07**	1.89**	-2.42**	-3.59**	3.60**	-8.00**	1.72*	-3.35**	-3.98**	-9.38**	-11.85**	-13.99**
P4 x P7	-11.04**	0.45	-12.99**	-1.69*	-9.28**	-7.37**	-8.76**	0.57	-13.44**	-3.59**	-7.87**	-6.40**	-5.92**	-0.44	-13.87**	-5.86**	-5.92**	-9.96**
P4 x P8	-1.77*	0.91	1.45*	2.96**	8.05**	-1.05	0.00	2.84**	1.38*	2.59**	5.13**	-1.60	37.95**	31.07**	27.82**	23.46**	32.51**	9.47**
P4 x P9	1.82*	1.81*	-3.42**	3.45**	16.60**	1.05	3.79**	3.79**	1.20	1.20	11.31**	-0.27	14.00**	14.00**	5.78**	5.78**	15.30**	2.05
P5 x P6	17.48**	14.29**	19.75**	18.61**	26.45**	7.37**	14.37**	13.07**	15.96**	14.57**	17.42**	4.27**	12.55**	6.94**	6.65**	0.65	0.80	-6.01**
P5 x P7	1.85**	12.24**	5.51**	17.15**	11.34**	13.68**	12.64**	11.36**	4.42**	13.17**	7.87**	9.60**	5.47**	8.38**	1.79	2.33*	4.36**	-2.69**
P5 x P8	4.85**	7.71**	8.43**	10.05**	13.79**	4.21**	4.42**	7.39**	6.51**	7.78**	10.26**	3.20**	14.53**	8.82**	10.27**	6.50**	17.65**	-2.80**
P5 x P9	-4.99**	-4.99**	0.49	0.51	3.24*	-10.53**	-2.27**	-2.27**	-1.20	-1.20	2.68**	-8.00**	-2.39**	-2.39**	-10.30**	-10.30**	-4.68**	-15.63**
P6 x P7	0.70	-2.04**	1.98**	1.01	16.12**	-1.40	-0.57	-1.70**	2.63**	1.40	9.61**	-2.67**	13.56**	7.90**	7.95**	1.87	-1.64*	-5.86**
P6 x P8	0.93	-1.81*	3.70**	2.71**	9.09**	-7.37**	0.57	-0.57	3.23**	2.00**	6.01**	-5.87**	9.91**	4.43**	3.77**	-2.07*	5.06**	-13.20**
P6 x P9	-2.80**	-5.44**	-2.22**	-3.15**	2.07	-13.33**	-2.87**	-3.98**	-2.22**	-3.39**	1.20	-10.13**	-7.89**	-12.49**	-11.72**	-16.70**	-12.73**	-22.75**
P7 x P8	-7.28**	-4.76**	-6.75**	-5.36**	-8.81**	-16.49**	-7.55**	-4.92**	-5.13**	-3.99**	-5.70**	-11.73**	-3.32**	-8.14**	-14.03**	-16.96**	-4.06**	-20.74**
P7 x P9	-1.36	-1.36	-0.98	-0.95	-0.40	-13.68**	-1.14*	-1.14*	-1.40*	-1.40	1.49	-9.07**	4.51**	4.51**	0.54	0.53	11.97**	-0.90
P8 x P9	0.46	0.45	0.49	0.51	-2.43	-15.44**	1.14*	1.14**	0.60	0.60	-0.30	-10.67**	10.50**	4.99**	4.12**	0.57	9.26**	-9.74**

Table 2: Estimates of heterosis over better parent (BPH) and standard check (SH) of the diallel set of crosses in boro rice for yield and yield related traits

	Effective tillers/plant						Panicle length						Flag leaf length					
	Boro- 2014		Boro-2015		Kharif-2015		Boro- 2014		Boro-2015		Kharif-2015		Boro- 2014		Boro-2015		Kharif-2015	
Cross	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH
P1 x P2	-12.93	-33.99**	-11.69	-24.01**	-7.86	-17.70*	-0.76	-3.53	-20.32**	-18.77**	-27.73**	-20.29**	-54.77**	-46.36**	-47.82**	-51.14**	-1.29	-8.57
P1 x P3	-3.96	-15.47*	-4.40	-10.66	-27.70**	-30.34**	-7.58	-10.16*	-9.29*	4.01	-15.72**	0.15	-16.59**	-5.28	3.06	-5.60	9.13	1.07
P1 x P4	-17.04*	-35.29**	-2.66	-17.23**	-5.18	-2.25	-20.53**	-6.48	-7.93	-3.83	-25.66**	-12.65**	-70.54**	-42.59**	-47.94**	-28.94**	-47.21**	-23.45**
P1 x P5	7.49	-12.42	-14.96*	-14.77*	17.68*	2.81	18.18**	14.87**	20.12**	19.25**	2.99	11.47*	-21.32**	-13.32*	14.62	4.99	21.08**	12.14**
P1 x P6	-8.67	-22.00**	1.20	-13.12*	30.93**	37.92**	-4.02	1.91	-4.55	-0.58	-11.68**	-4.41	-56.06**	-57.66**	-27.44**	-33.54**	-45.50**	-49.52**
P1 x P7	26.14**	-9.59	5.48	-9.02	13.08	16.57*	6.44	11.93*	2.46	11.11*	-17.28**	2.79	-23.03**	-11.81*	11.84	2.44	-42.49**	-30.24**
P1 x P8	-21.64**	-35.29**	-8.70	-13.74*	-14.74*	-2.53	2.09	0.88	-0.30	-1.02	-5.43	2.35	-46.64**	-44.10**	-22.14**	-28.69**	-14.01**	-20.36**
P1 x P9	-12.85	-12.85	-12.32*	-12.30*	36.09**	38.76**	-7.07	-7.07	-4.14	-4.13	2.58	11.03*	2.51	2.51	-7.02	-7.00	15.17**	6.67
P2 x P3	-4.46	-15.90*	7.91	0.84	-17.78*	-20.79**	0.94	-5.30	-3.87	10.22*	-8.91*	8.24	10.17*	30.65**	28.75**	20.55**	-26.51**	-37.62**
P2 x P4	40.50**	9.59	9.55	-5.73	-4.09	-1.12	-23.28**	-9.72	14.16**	19.25**	-13.52**	1.62	-30.11**	36.18**	-1.12	34.97**	-5.09	37.62**
P2 x P5	16.31*	-5.23	-12.70*	-12.51*	26.42**	12.92	22.58**	13.55**	8.13	10.22*	3.20	13.82**	-18.96**	-3.89	11.17	4.09	15.29**	-2.14
P2 x P6	-7.91	-21.35**	-3.58	-17.03**	-1.33	3.93	-4.99	0.88	-1.42	2.68	-6.13	3.53	-46.50**	-36.56**	-21.39**	-26.39**	4.77	-11.07*
P2 x P7	-12.93	-33.99**	1.67	-12.30*	36.24**	40.45**	-3.78	1.18	-20.19**	-13.45**	-20.59**	-1.32	-23.94**	-9.80	10.76	3.71	-22.87**	-6.43
P2 x P8	-39.31**	-49.89**	-6.09	-11.28	-9.83	3.09	-0.60	-1.77	0.87	2.83	-24.67**	-16.91**	3.50	22.74**	6.27	-0.50	11.50*	-5.36
P2 x P9	-22.00**	-22.00**	-29.98**	-29.96**	19.28*	21.63**	-19.73**	-19.73**	-14.51**	-12.86**	-34.27**	-27.50**	-11.55**	4.90	15.56	15.58**	19.07**	1.07
P3 x P4	9.90	-3.27	-30.33**	-34.89**	23.16**	26.97**	-14.39**	0.74	-16.13**	-3.83	-6.93	10.59*	-52.93**	-8.29	-26.92**	-0.24	-47.04**	-23.21**
P3 x P5	-24.01**	-33.12**	-14.96*	-14.77*	32.07**	27.25**	3.14	-3.24	-16.52**	-4.28	-9.16*	7.94	-22.01**	-11.43*	0.85	-24.74**	-2.90	-24.29**
P3 x P6	2.72	-9.59	-9.01	-14.97*	26.40**	33.15**	11.23*	18.11**	2.19	17.18**	-13.99**	2.21	-0.88	12.56*	66.73**	21.44**	-3.21	-24.52**
P3 x P7	11.88	-1.53	-7.03	-13.12*	13.62	17.13*	-14.57**	-10.16*	-22.45**	-11.08*	-24.50**	-6.18	-23.25**	-12.06*	2.63	-15.30**	-48.97**	-38.10**
P3 x P8	1.49	-10.68	-16.09*	-20.72**	4.67	19.66*	11.03*	9.72	-3.10	11.11*	-11.63**	5.00	-19.25**	-8.29	25.74**	-8.41	-14.96*	-33.69**
P3 x P9	-24.84**	-24.84**	2.67	2.69	-5.23	-3.37	14.73**	14.73**	-6.45	7.26	-9.53*	7.50	-31.31**	-21.98**	-39.29**	-39.28**	-7.79	-28.10**
P4 x P5	-22.19**	-36.60**	-10.45	-10.25	23.43**	27.25**	-30.66**	-18.41**	-15.44**	-11.67*	-28.91**	-16.47**	-30.30**	35.80**	3.46	41.22**	-27.75**	4.76
P4 x P6	-5.36	-19.17**	11.48	-4.29	13.07	19.10*	-19.27**	-5.01	-11.61*	-7.68	-22.78**	-9.26	-80.08**	-61.18**	-73.83**	-64.28**	-71.51**	-58.69**
P4 x P7	15.08*	-10.24	-0.95	-14.56*	-5.99	-3.09	-20.03**	-5.89	-19.37 **	-12.56**	-23.55**	-5.00	-73.63**	-48.62**	-58.88**	-43.87**	-49.92**	-27.38**
P4 x P8	-15.30*	-30.07 **	-6.74	-11.89*	-8.85	4.21	-9.39*	6.63	5.38	10.08*	-3.75	13.09**	-51.19**	-4.90	-27.38**	-0.88	-25.12**	8.57
P4 x P9	-16.99*	-16.99 *	-1.03	-1.01	17.71*	21.35**	-32.67**	-20.77**	-17.85 **	-14.19**	-40.30**	-29.85**	-31.21**	34.05**	16.45**	58.95**	-15.27**	22.86**
P5 x P6	-5.36	-19.17 **	-35.04**	-34.89**	-16.00*	-11.52	2.36	8.69	18.61 **	23.54**	-2.05	-1.62	37.97**	52.01**	138.12 **	77.70**	138.10**	42.86**

P5 x P7	-2.14	-20.26 **	-26.64 **	-26.47**	-7.63	-4.78	-4.62	0.29	3.27	12.00**	-11.72 **	9.71 *	33.44 **	52.89**	70.17 **	40.45**	-7.07	12.74**
P5 x P8	14.51	-5.45	0.82	1.05	12.04	28.09**	8.64	7.36	8.12	6.38	-1.51	5.59	-12.20 **	-3.27	45.13 **	8.30	98.21**	18.93**
P5 x P9	-18.30 **	-18.30 **	7.17	7.41	3.58	5.62	18.11**	18.11**	19.82 **	19.84**	22.64 **	18.68 **	-19.61 **	-11.43*	-6.76	-6.75	74.21**	4.52
P6 x P7	-19.64 *	-31.37 **	-7.14	-19.90**	19.47*	25.84**	16.50**	23.71**	12.41 **	21.91**	-5.68	17.21 **	-53.95 **	-47.24**	-38.18 **	-48.97**	-61.83**	-53.69 **
P6 x P8	9.69	-6.32	-1.52	-6.96	4.67	19.66*	1.25	7.51	0.14	4.31	-4.66	2.21	-37.89 **	-34.92**	-2.83	-38.77**	90.41**	-5.48
P6 x P9	-6.75	-6.75	-21.15 **	-21.13**	12.27	18.26*	-5.69	0.15	-2.41	1.64	-1.32	-0.88	-49.25 **	-49.25**	-38.52 **	-38.51**	18.07*	-33.10 **
P7 x P8	30.87 **	8.06	-7.61	-12.71*	-6.14	7.30	17.93**	24.01**	6.82	15.85**	-13.49 **	7.50	-53.29 **	-46.48**	-14.99 **	-29.84**	-33.95**	-19.88 **
P7 x P9	-3.49	-3.49	-6.16	-6.14	22.34**	26.12**	-7.84	-3.09	-9.28 *	-1.61	-25.68 **	-7.65	-62.83 **	-57.41**	-43.37 **	-43.36**	-51.13**	-40.71 **
P8 x P9	0.65	0.65	-1.85	-1.83	16.46*	33.15**	12.37*	12.37*	7.99	8.00	-2.47	4.56	-44.96 **	-42.34**	-29.21 **	-29.20**	24.79**	-29.29 **

*p≤0.05; **p≤0.01; P1-IR 8; P2-IR 36; P3-IR-64; P4-HUR 36; P5-HUR 105; P6-MTU 1010; P7-Jaya; P8- Krishna Hamsa; P9- Gautam

	Flag leaf width						**Grains/panicle**						**100 Seed weight**					
	Boro- 2014		**Boro-2015**		**Kharif-2015**		**Boro- 2014**		**Boro-2015**		**Kharif-2015**		**Boro- 2014**		**Boro-2015**		**Kharif-2015**	
Cross	**BPH**	**SH**	**BPH**	**SH**	**BPH**	**SH**	**BPH**	**SH**	**BPH**	**SH**	**BPH**	**SH**	**BPH**	**SH**	**BPH**	**SH**	**BPH**	**SH**
P1 x P2	-7.69	9.09	-38.46 **	-31.62**	-4.88	0.00	-23.95**	-29.68 **	-13.96**	-25.02**	-6.70	-13.19**	-13.21 **	-21.49 **	27.53 **	18.76**	-25.57 **	-26.33 **
P1 x P3	7.69	27.27 **	-25.00 **	-14.53*	2.44	7.69	-2.88	-7.53	-14.59**	-19.71**	-22.05 **	-16.07**	-13.47 **	-16.55 **	-17.89 **	-17.60**	-10.21 **	-11.12 **
P1 x P4	-7.69	9.09	-18.18 *	-23.08**	2.44	7.69	-44.84**	-14.61 **	-44.53**	-19.27**	-56.31 **	-22.78**	9.78**	-0.69	9.01**	1.52	-7.22**	-8.17 **
P1 x P5	7.69	27.27 **	-17.50 *	-5.98	-12.20	-7.69	9.33 *	4.34	11.68**	-2.68	-18.47 **	-13.19**	7.12**	-3.10**	26.53 **	17.83**	-26.49 **	-27.24 **
P1 x P6	-30.77**	-18.18 *	8.33	11.11	9.76	15.38*	-2.79	-12.56 **	0.96	-6.88	-16.38 **	-17.99**	10.37 **	0.34	27.78 **	19.00**	12.16 **	11.01 **
P1 x P7	-5.13	12.12	-15.38 *	-5.98	-34.15**	-30.77**	-21.35**	-20.09 **	-8.50 *	-16.61**	-25.39 **	-19.66**	-4.19**	-13.33 **	28.73 **	24.83**	16.86 **	15.66 **
P1 x P8	-15.38	0.00	-9.09	-14.53*	-26.83**	-23.08**	-1.48	-8.68*	-4.95	-15.06**	-0.26	-7.19	2.30**	2.41**	2.74**	4.90 **	0.46	-0.57
P1 x P9	-7.69	9.09	5.71	5.41	-34.15**	-30.77**	-48.40**	-48.40 **	-18.58**	-18.60**	-24.48 **	-29.74**	1.03	1.03	3.38**	3.38 **	-5.62**	-6.58 **
P2 x P3	-5.41	6.06	-17.50 *	-5.98	9.09	-7.69	-5.52	-10.05 *	-14.59**	-19.71**	-14.70 **	-8.15 *	-3.10**	-6.55**	-19.86 **	-19.58**	-7.37**	-20.09 **
P2 x P4	10.81	24.24 *	-10.26	-0.28	9.09	-7.69	-32.15**	5.02	-51.06**	-28.78**	-48.58 **	-9.11 *	5.97**	-12.30 **	-8.64 **	-21.10**	-1.63**	-24.74 **
P2 x P5	21.62*	36.36 **	-7.50	5.41	-30.77**	-30.77**	17.22**	11.87 **	11.08**	-4.67	-13.51 **	-7.91 *	16.07 **	3.79**	22.13 **	5.48 **	23.57 **	-4.20 **
P2 x P6	5.41	18.18 *	2.56	13.96	18.18*	0.00	75.06**	61.87 **	-23.98**	-29.88**	-6.36	-8.15 *	12.39 **	2.18**	15.81 **	2.45 **	21.22 **	-7.26 **
P2 x P7	-17.95*	-3.03	0.00	11.11	27.27**	7.69	-42.47**	-41.55 **	-17.23**	-24.57**	-30.51 **	-25.18**	9.67**	-4.83**	-0.96	-3.96 **	-11.68 **	-14.19 **
P2 x P8	7.69	27.27 **	-10.26	-0.28	9.09	-7.69	-11.08**	-17.58 **	-4.70	-14.84**	-6.23	-13.43**	5.17**	5.29**	3.88**	6.06 **	25.82 **	-3.75 **
P2 x P9	-10.81	0.00	-30.77 **	-23.08**	18.18*	0.00	-34.02**	-34.02 **	-20.58**	-20.59**	-20.62 **	-26.14**	1.38*	1.38*	2.33**	2.33 **	20.62 **	-7.72 **
P3 x P4	0.00	9.09	-17.50 *	-5.98	9.09	-7.69	-45.87**	-16.21 **	-50.91**	-28.56**	-43.96 **	-0.96	7.99**	4.14**	4.76**	5.13 **	11.97 **	-3.41 **
P3 x P5	-8.33	0.00	-17.50 *	-5.98	0.00	0.00	-33.97**	-36.99 **	-39.06**	-42.71**	-27.39 **	-21.82**	13.59 **	9.54**	18.00 **	18.41**	-9.47**	-21.91 **
P3 x P6	0.00	9.09	5.00	19.66*	0.00	-15.38*	5.52	0.46	-8.71 *	-14.18**	-14.70 **	-8.15 *	12.28 **	8.28**	30.08 **	30.54**	-1.18*	-14.76 **
P3 x	-	0.00	-	-	24.2	5.13	-	-0.91	11.5	4.84	-11.14	-	0.95	-	-0.35	0.00	-	-11.58

P7	15.38		32.50**	23.08**	4**		2.47		3**		**	4.32		2.64**			10.67**	**
P3 x P8	7.69	27.27**	-2.50	11.11	27.27**	7.69	-8.39*	-12.79**	-16.47**	-21.48**	-21.16**	-15.11**	0.23	0.34	-0.23	1.86*	-0.26	-13.96**
P3 x P9	8.33	18.18*	-32.50**	-23.08**	9.09	-7.69	-18.49**	-18.49**	-17.04**	-17.05**	-15.37**	-8.87*	-16.44**	-16.44**	-33.10**	-32.87**	-7.89**	-20.54**
P4 x P5	0.00	9.09	-17.50*	-5.98	0.00	0.00	-60.91**	-39.50**	-61.40**	-43.82**	-59.70**	-28.78**	7.97**	-3.45**	14.46**	-2.21**	13.62**	-11.92**
P4 x P6	12.50	9.09	0.00	2.56	20.00*	-7.69	-54.72**	-29.91**	-61.55**	-44.04**	-46.95**	-6.24	2.91**	-6.44**	8.30**	-4.20**	16.59**	-13.05**
P4 x P7	-28.21 **	-15.15	-23.08**	-14.53*	9.09	-7.69	-61.50**	-40.41**	-48.94**	-25.68**	-50.88**	-13.19**	15.23**	0.00	5.17**	1.98*	-4.56**	-7.26**
P4 x P8	-10.26	6.06	9.09	2.56	-10.00	-30.77**	-42.92**	-11.64**	-36.63**	-7.76	-40.57**	5.04	-5.05**	-4.94**	-6.39**	-4.43**	12.22**	-14.53**
P4 x P9	3.03	3.03	2.86	2.56	0.00	-15.38*	-56.05**	-31.96**	-59.12**	-40.50**	-53.60**	-17.99**	-11.49**	-11.49**	-11.31**	-11.31**	10.03**	-19.07**
P5 x P6	-25.00 **	-18.18*	-2.50	11.11	7.69	7.69	2.87	-1.83	-5.76	-13.07**	-14.64**	-9.11*	-30.59**	-36.90**	-8.56**	-19.11**	-6.30**	-27.36**
P5 x P7	-15.38	0.00	-2.50	11.11	7.69	7.69	-4.94	-3.42	-15.53**	-23.03**	-14.48**	-7.91*	-31.75**	-38.97**	-21.88**	-24.24**	-6.19**	-8.85**
P5 x P8	-7.69	9.09	-10.00	2.56	-30.77**	-30.77**	4.07	-0.68	6.68	-4.67	-1.58	4.80	1.49*	1.61**	6.05**	8.28**	27.82**	-0.91
P5 x P9	8.33	18.18*	-5.00	8.26	7.69	7.69	9.36*	9.36*	13.27**	13.25**	-4.05	2.16	3.68**	3.68**	4.08**	4.08**	19.33**	-7.49**
P6 x P7	7.69	27.27**	-7.69	2.56	0.00	-15.38*	-17.75**	-16.44**	-12.71**	-19.49**	-12.69**	-6.00	15.93**	5.40**	9.98**	6.64**	-0.12	-2.95**
P6 x P8	-7.69	9.09	25.00**	28.21**	44.44**	0.00	3.20	-4.34	0.24	-7.54	-3.42	-5.28	-1.49*	-1.38*	-4.00**	-1.98*	15.95**	-11.69**
P6 x P9	18.18*	18.18*	16.67*	19.66*	9.09	-7.69	-4.57	-4.57	-13.94**	-13.96**	-12.96**	-14.63**	1.38*	1.38*	1.75*	1.75*	22.37**	-8.74**
P7 x P8	-15.38	0.00	-30.77**	-23.08**	18.18*	0.00	5.39	7.08	8.74*	-0.91	-5.35	1.92	-1.26*	-1.15	-4.34**	-2.33**	-7.59**	-10.22**
P7 x P9	-38.46 **	-27.27**	-15.38*	-5.98	0.00	-15.38*	-1.12	0.46	-8.63*	-8.65	-16.26**	-9.83**	2.53**	2.53**	2.68**	2.68**	-11.45**	-13.96**
P8 x P9	-7.69	9.09	11.43	11.11	0.00	-15.38*	-2.05	-2.05	1.77	1.75	4.90	-2.40	7.00**	7.13**	5.02**	7.23**	11.77**	-14.87**

*p≤0.05; **p≤0.01; P1-IR 8; P2-IR 36; P3-IR-64; P4-HUR 36; P5-HUR 105; P6-MTU 1010; P7-Jaya; P8- Krishna Hamsa; P9- Gautam

	Yield/plant						Chlorophyll Content					
	Boro- 2014		Boro-2015		Kharif-2015		Boro- 2014		Boro-2015		Kharif-2015	
Cross	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH	BPH	SH
P1 x P2	-29.25**	-34.50**	-29.46**	-37.54**	-22.34**	-30.57**	9.23**	-18.28**	-4.52*	-16.15**	1.24	-6.85**
P1 x P3	-51.34**	-54.36**	-36.24**	-39.09**	-6.98	-14.01*	-4.05	-27.83**	-12.08**	-22.79**	-2.58	-20.05**
P1 x P4	-24.81**	-30.39**	-22.16**	-23.67**	-16.44*	-18.88**	20.09**	-10.16**	-1.79	-13.76**	14.55**	-7.58**
P1 x P5	-18.63**	-24.67**	9.81	-5.54	-1.21	-10.60	14.93**	-14.01**	-4.75**	-16.36**	9.49**	-11.65**
P1 x P6	4.99	3.31	-2.79	-5.25	4.84	-2.44	8.78**	-18.62**	-2.96	-14.78**	3.22	4.56*
P1 x P7	-19.71**	-22.77**	-37.94**	-39.09**	-15.86**	-12.79*	14.84**	-14.08**	3.35	-9.24**	17.20**	-5.05*
P1 x P8	6.43	1.30	4.71	-5.15	-6.48	-6.82	-4.16	-28.30**	-5.14**	-16.70**	4.41	-5.38**
P1 x P9	-21.16**	-21.16**	-6.11	-6.12	22.17**	16.81**	-18.82**	-18.82**	-23.68**	-23.68**	1.18	4.48*
P2 x P3	-30.70**	-35.01**	-27.92**	-31.14**	2.77	-4.99	-1.53	-25.93**	-2.59	-20.19**	14.17**	5.05*
P2 x P4	-34.74**	-44.23**	-31.95**	-33.28**	-3.26	-6.09	10.38**	-20.11**	-3.28	-23.41**	10.81**	1.96
P2 x P5	6.10	-9.33	6.13	-6.02	29.07**	16.81**	10.00**	-18.08**	-2.74	-14.92**	0.27	-7.74**
P2 x P6	13.24*	14.95*	-17.11**	-19.21**	33.90**	24.60**	-2.89	-29.52**	-7.17**	-26.49**	-19.55**	-18.50**
P2 x P7	-3.55	-7.22	-16.50**	-18.05**	-15.39*	-12.30	28.65**	-6.36**	9.94**	-12.94**	4.07	-4.24*
P2 x P8	8.64	3.41	-0.64	-10.00	14.43*	14.01*	0.74	-25.86**	-3.98*	-23.96**	0.18	-7.82**
P2 x P9	-20.36**	-20.36**	-23.57**	-23.58**	-16.31*	-19.98**	-14.56**	-14.56**	-14.72**	-14.72**	-1.97	1.22
P3 x P4	-8.34	-14.04*	-25.02**	-	4.64	1.58	0.09	-24.71**	-2.42	-	21.05**	-0.65

				26.49**						20.05**		
P3 x P5	2.67	-3.71	-21.02**	-24.55**	14.10*	5.48	9.54**	-17.60**	-8.92**	-20.33**	8.84**	-10.68**
P3 x P6	-27.22**	-28.39**	27.76**	24.53**	3.93	-3.29	6.12**	-20.18**	13.87**	-6.71**	2.33	3.67
P3 x P7	11.31	9.53	-35.77**	-36.96**	26.20**	30.82**	13.77**	-14.42**	2.26	-16.22**	8.74**	-10.76**
P3 x P8	-3.69	-8.32	-9.95	-13.98*	2.44	2.07	12.33**	-15.50**	14.79**	-5.95**	15.38**	4.56*
P3 x P9	-14.94*	-14.94*	-32.20**	-32.21**	-0.13	-4.51	-20.92**	-20.92**	-12.73**	-12.73**	1.50	4.81*
P4 x P5	-6.15	-20.46**	-18.00**	-19.60**	3.39	0.37	0.36	-25.25**	-13.85**	-24.64**	34.62**	4.89*
P4 x P6	-56.37**	-57.07**	-48.86**	-49.86**	-23.46**	-25.70**	27.80**	-7.24**	15.69**	-10.68**	-2.49	-1.22
P4 x P7	-31.28**	-33.90**	-25.40**	-26.78**	-10.81	-7.55	14.98**	-16.32**	19.09**	-15.88**	8.95**	-11.74**
P4 x P8	-22.76**	-26.48**	-9.40	-11.16	2.20	1.83	13.80**	-16.25**	27.25**	-4.11**	16.37**	5.46**
P4 x P9	-25.78**	-25.78**	-50.05**	-50.05**	-10.41	-13.03*	-14.69**	-14.69**	-9.65**	-9.65**	-8.21**	-5.22**
P5 x P6	-29.26**	-30.39**	-26.17**	-28.04**	-2.49	-9.26	1.91	-24.10**	-16.90**	-27.31**	-8.69**	-7.50**
P5 x P7	-6.78	-10.33	-26.98**	-28.33**	-13.40*	-10.23	15.09**	-14.29**	-2.43	-14.65**	33.60**	8.23**
P5 x P8	-6.22	-10.73	29.66**	17.45**	28.73**	28.26**	11.82**	-16.72**	5.79**	-7.46**	20.77**	9.45**
P5 x P9	-0.40	-0.40	28.90**	28.89**	22.29**	16.93**	-12.05**	-12.05**	-0.21	-0.21	-2.29	0.90
P6 x P7	-4.99	-6.52	24.11**	21.81**	18.21**	22.53**	4.00	-24.31**	8.78**	-16.02**	-7.32**	-6.11**
P6 x P8	-17.84**	-19.16**	22.99**	19.87**	16.63**	16.20**	6.99**	-21.26**	3.19	-20.33**	-6.84**	-5.62**
P6 x P9	20.16**	20.16**	16.78**	16.77**	19.11**	13.89*	-16.45**	-16.45**	-10.27**	-10.27**	-7.26**	-4.24*
P7 x P8	29.41**	24.47**	26.48**	24.14**	23.97**	28.50**	8.28**	-20.31**	12.72**	-15.06**	3.42	-6.28**
P7 x P9	34.60**	34.60**	6.98	6.98	5.64	9.50	-5.82**	-5.82**	0.89	0.89	10.81**	14.43**
P8 x P9	19.56**	19.56**	49.08**	39.66**	3.79	3.41	-24.71**	-24.71**	-15.33**	-15.33**	-9.94**	-7.01**

*$p \leq 0.05$; **$p \leq 0.01$; P1-IR 8; P2-IR 36; P3-IR-64; P4-HUR 36; P5-HUR 105; P6-MTU 1010; P7-Jaya; P8- Krishna Hamsa; P9- Gautam

CONCLUSION

The present study revealed that desirable performance for yield and all the yield related traits were not expressed in a single cross combination over seasons. Crosses showed differential performance over seasons for different traits and the magnitude of heterosis varied from cross to cross. Among top performing croses, Jaya x Krishna Hamsa showed consistent significant standard heterosis over the three seasons for grain yield/plant. The promising crosses may further be tested on larger scale for commercial exploitation.

Acknowledgement

The first author is thankful to the Department of Science and Technology, New Delhi, India for financial assistance as INSPIRE Fellowship and Department of Genetics and Plant Breeding, BHU for providing facilities for conducting experiments during the course of present study.

REFERENCES

1. Anand, K., and Singh, N. K., Standard heterosis of rice hybrids for yield and yield components. *J. Appl. Biol.*, **12(1-2)**: 20-22 (2002).
2. Bagheri, N., and Babaeian-Jelodar, N., Heterosis and combining ability analysis for yield and related-yield traits in hybrid rice. *International Journal of Biology*, **2 (2)**, p222 (2010).
3. Bisne, R., Motiramani, N. K., Sarawgi, A. K., Evaluation of standard heterosis in hybrid rice. *Adv. Plant Sci*., **21(1)**: 155-156 (2008).
4. Faiz, F. A., Sabar, M., Awan, T. H., Ijaz, M., and Manzoor, M., Heterosis and Combining ability analysis in Basmati rice hybrids. *J. Anim. Pl. Sci.*, **16(1-2)**: 56-59 (2006).
5. Khoyumthem, P., Sharma, P. R., Singh, N. B., and Singh, M. R. K., Heterosis for grain yield and its component characters in rice (*Oryza sativa* L.). *Environ. Ecol.*., **23 (4)**: 687-691 (2005).
6. Khush, G.S., and Brar, D.S., Biotechnology for rice breeding: progress and impact. In: Sustainable rice production for food security. Proceedings of the 20th Session of the International Rice

Commission. Bangkok, Thailand, July, 23-26 (2002).

7. Kumar, S., Satish, K., Narendra, P., and Dwivedi, D. K., Estimation of heterosis for grain yield and yield attributing traits in rice (*Oryza sativa* L.). *Plant Archives*, **12 (1)**: 159-164 (2012).
8. Malarvizhi, D., Thiyarajan, K., Vijayalakshmi, C., and Manonmani, S., Exploration of heterosis for yield and morpho-physiological traits in hybrid rice (*Oryza sativa* L.): A comparative study under flooded and aerobic conditions. *Indian journal of Genetics*, **69(4)**: 371-382 (2009).
9. Malini, N., Sundaram, T., Hari, S. R., and Saravanan, S., Genetic Interpretation of Yield Related Traits in Rice (Oryza *sativa* L.). *Res. J. Agril. Biolog. Sci.,* **2(4)**: 153-155 (2006).
10. Narasimman, R., Kumar, Thirugnana S., Eswarn R., Sampath Kumar, Praveen C., and Anandan A., Combining ability and heterosis for grain yield and its component characters in rice (*Oryza sativa L.*). *Crop improvement*, **34(1)**:16-18 (2007).
11. Priyanka, K., Jaiswal, H.K., and Waza, S.A., Combining ability and heterosis for yield, its component traits and some grain quality parameters in rice (*Oryza sativa* L.). *J. Appl. & Nat. Sci.,* **6(2)**:495-506 (2014).
12. Saleem, M.Y., Mirza, J. I., and Haq, M. A., Heritability, genetic advance and Heterosis. *J. Agric. Res.,* **46**: 15-27 (2008).
13. Saravanan, K., Sabesan, T., and Kumar, S. T., Heterosis for yield and yield components in rice (*Oryza sativa* L.). *Adv. Plant Sci*., **21(1)**: 119-121 (2008).
14. Sravan, T., Jaiswal, H.K., Waza, S.A., and Priyanka, K., Heterosis for yield and yield attributes in rice (*Oryza sativa* L.). *Journal of Applied and Natural Science.* **8(2)**:622-625 (2016).
15. Tiwari, D. K., Pandey, P., Giri, S.P., and Dwivedi, J.L., Heterosis studies for yield and its components in rice hybrids using CMS system. *Asian Journal of PlantSciences*, **10(1)**: 29-42 (2011).
16. Vanaja, T., and Babu, L. C., Heterosis for yield and yield components in rice (*Oryza sativa* L.). *J. Trop. Agric*., **42(1-2)**: 43- 44 (2004).
17. Vanaja, T., Babu, L.C., Radhakrishnan, V.V., and Pushkaran, K., Combining ability analysis for yield and yield components in rice varieties of diverse origin. *Journal of Tropical Agriculture,* **41**:7-15 (2003).
18. Veeresha, B.A., Hanamaratti, N.G., Salimath, P.M., and Chetti, M.B., Heterosis for yield and yield traits in hybrid rice (*Oryza sativa* L.) under aerobic condition. *Bioinfolet,* **10 (2A)**: 521-529 (2013).
19. Venkatesan, M., Anbuselvam, Y., Murugan, S., and Palaniraja, K., Heterosis for yield, its components and grain traits in rice (*Oryza sativa* L.). *Oryza,,* **45(1)**: 76-78 (2008).
20. Waza, S.A., Jaiswal, H.K., Sravan, T., Bano, D.A., Priyanka, K., and Umesh, Heterosis for yield and quality traits in rice (*Oryza sativa* L.). *Journal of Applied and Natural Science*. **8(3)**: 1510-1522 (2016).