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Heterosis for grain yield and yield components in rice (*Oryza sativa* L)

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Abstract
Rice (Oryza sativa, 2n = 24) is one of the world's most important staple cereal food crop growing in at least 114 countries under diverse conditions. Rice is not only the staple food for more than 70 per cent of the Indians but also a source of livelihood for millions of rural households. Globally it is cultivated in an area of 161.8 m ha with an annual production of about 748.0 million tones and an average productivity of 4.6 t ha -1 .Among the rice producing countries India ranks first in the world in area of rice cultivation with44.2 mha and second in production with 104.32 million tons. Heterosis and combining ability are thus, excellent tools which help discern the goal and direction in a breeding programme. In plant breeding programme, exploitation of heterosis is vital and considered to be one of the greatest outstanding achievements. Heterosis is an universal phenomenon and exploitation of heterosis is a quick and convenient way of combining desirable characters and hence assumes greater significance in the development of hybrids. The interaction due to lines x testers were significant for all the traits studied except panicle length. Interaction effects of Parents vs. crosses were significant for all the characters, except flag leaf length. High heterosis over Jaya and IR 64 was shown by the four hybrids NLR 34449 x SHIATS Dhan1 (20.58% and 13.74%) followed by Sahabhagi dhan x SHIATS Dhan1 (16.62% and 9.82%), BPT 2615 x NDR 359 (14.58% and 8.09 %) and MTU 1010 x BM 71 (13.63% and 7.19 %). These hybrids can be be used for exploitation of heterosis for yield and its components traits in rice.

Keywords: Heterosis, combining ability, crosses, grain yield

Introduction
Rice (*Oryza sativa*, 2n = 24) is one of the world's most important staple cereal food crop growing in at least 114 countries under diverse conditions (Anon., 2013) [1]. Rice is also called "Grain of Life", because it is not only the staple food for more than 70 per cent of the Indians but also a source of livelihood for millions of rural households. Globally it is cultivated in an area of 161.8 m ha with an annual production of about 748.0 million tones and an average productivity of 4.6 t ha^{-1} (FAO, 2016) [3]. Among the rice producing countries India ranks first in the world in area of rice cultivation with 44.2 mha and second in production with 104.32 million tons (Directorate of Economics and Statistics, 2016-17) [2]. To make India self-sufficient in rice, it is needed to improve the productivity to a greater extent (Hossain, 1996). The task is quite challenging and the options available are very limited. With the current green revolution technologies, it is estimated that by 2020 at least 115-120 million tons of milled rice is to be produced in India to maintain the present level of self-sufficiency. There is need for a paradigm shift in rice research to meet the challenges of the future decades for ensuring food security. The success of any crop breeding depends on the magnitude of genetic variability and the extent to which the desirable genes are heritable nature and amount of variability existing in the germplasm. Heterosis refers to the manifestation of superiority of F_1 performance over its parent in respect to yield, growth rate, vigour etc. The exploitation of heterosis is primarily depend on the screening and selection of available germplasm that could be produced better combination of important agronomic characters. In the modern era hybridization is the most common method applied in crop improvement and large numbers of varieties have been developed in various crops by hybridization. Heterosis and combining ability are thus, excellent tools which help discern the goal and direction in a breeding programme. In plant breeding programme, exploitation of heterosis is vital and considered to be one of the greatest outstanding achievements.

Materials and Methods
The experimental findings of the present investigation was carried out using 100 genotypes of rice evaluated during *kharif,* 2014 at SHUATS, Allahabad for yield and yield attributing traits

and identified 10 genotypes for further experimentation. Identified 7 lines and 3 testers were used to develop 21 F_1hybrids in line x tester mating design during *kharif*, 2015 at Field Experimentation Centre, Department of Genetics and Plant Breeding, Naini Agricultural Institute, SHUATS, Allahabad. Twenty one hybrids derived during *kharif*, 2015 along with ten parents and three checks namely (*viz.*, Jaya, IR 64 and Anjali) a total 34 genotypes were (*viz.*, Jaya, IR 64 and Anjali) a total 34 genotypes were evaluated in *Rabi*, 2015-16 at NRRI Cuttack. The data was recorded on 15 quantitative characters *viz.*, days to 50% flowering, plant height, number of tillers/plant, number of panicles/plant, panicle length, flag leaf length, flag leaf width, number of grains/panicle, days to maturity, spikelet fertility %, spikelet sterility %, biological yield, harvest index, test weight and grain yield/plant. The significance of different types of heterosis was carried out by adopting 't test' as suggested by Nadarajan and Gunasekaran (2005) as given below

$$\text{Heterosis (\%) } (H_{MP}) = \frac{F_1 - MP}{MP} \times 100$$

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

$$\text{Standard heterosis SH (\%)} = \frac{\overline{F_1} - \text{Mean of check}}{\text{Mean of check}} \times 100$$

Heterosis over mid parent average heterosis (AH), heterosis over better parent heterobeltiosis (HB) and heterosis over standard checks (Economic heterosis) *i.e.*, increased or decreased performance as desirable over the then mid parents, better parents and the best check (Anjali / Jaya / IR 64), Mean performance of hybrids along with their parental lines and checks were studied for both yield and quality traits. Heterosis was estimated for various yield and quantitative traits over respective better parent and over the standard varieties for all the 21 hybrids. Revealed marked differences in the nature and magnitude of heterosis among F_1hybrids for all the traits. The negative heterotic values for days to 50% flowering and plant height indicate earliness and short stature, respectively, which are desirable. For the other characters positive estimates were considered as desirable.

Results and discussion

The analysis of variance (Table 1) indicated that variances due to treatments parents, crosses, parents and hybrids were highly significant for all the characters. The variance due to parent vs. hybrids was also found highly significant for almost all the characters. The significant differences between lines x testers interaction indicates that SCA attributed heavily in the expression of these traits and demonstrates the importance of dominance or non-additive variances for all the traits. (Sanghera and Hussain, 2012) Commercial exploitation of hybrid vigor is feasible only if the vigor is in excess of prevailing better parent and commercial check. One of the major objective in plant breeding is to get higher grain yield per plant, therefore, emphasis was given in the present study for heterosis over better parent and standard check.

The hybrids those recorded significant standard negative heterosis over Jaya for fifty percent flowering were Sahabhagi dhan x SHIATS Dhan1 (-20.86), MTU 1010 x BM 71 (-14.57), Sahabhagi dhan x NDR 359 (-11.59), MTU 1001 x BM 71 (-10.60). BPT 2615 x NDR 359 (-6.29). When compared to Jaya, 7 hybrids registered significant positive standard heterosis with a range varying from -6.76 (NLR 34449 x BM 71) to 18.47 per cent (MTU 1001 x BM 71) for plant height. Standard heterosis over IR 64 ranged from -4.49 (NLR 34449 x NDR 359) to 32.02 per cent (MTU 1001 x BM 71) for number of grains per panicle. Three hybrids showed higher grain weight than standard checks Jaya and IR-64, respectively. The standard heterosis range was from -16.45 (MTU 1010 x BM 71) to 12.46 percent (MTU 1001 x NDR 359) and from -20.75 (MTU 1001 x BM 71) to 17.61 per cent (MTU 1010 x NDR 359) over Jaya and IR-64, respectively. High heterosis for grain yield per plant over Jaya and IR 64 was shown by the four hybrids NLR 34449 x SHIATS Dhan1 (20.58% and 13.74%) followed by Sahabhagi dhan x SHIATS Dhan1 (16.62% and 9.82%), BPT 2615 x NDR 359 (14.58% and 8.09 %) and MTU 1010 x BM 71 (13.63% and 7.19 %).Standard heterosis for grain yield per plant shown in table no 2.

Heterosis is an universal phenomenon and exploitation of heterosis is a quick and convenient way of combining desirable characters and hence assumes greater significance in the development of hybrids. Hybrids have become an integral part of agriculture to boost productivity as they would respond very well to higher fertilizer levels. The commercial exploitation of heterosis in rice has been a recent development. So that the crosses with high heterotic potential could be isolated for further evaluation and commercial cultivation. Magnitude of heterosis as such does not assure its commercial exploitation unless it is significantly superior over the standard check varieties. The success of developing commercial hybrid depends upon choice of superior parents coupled with cross potentiality as evident from economic heterosis. Therefore, it is prerequisite to know the basic information on the nature and magnitude of heterosis present in the crosses. Therefore, in present investigation, the performance of all the 21F_1 hybrids were compared with three standard checks, namely, Jaya, IR64 and Anjali. Revealed marked differences in the nature and magnitude of heterosis among F_1hybrids for all the traits.

The negative heterotic values for days to 50% flowering and plant height indicate earliness and short stature, respectively, which are desirable. For the other characters positive estimates were considered as desirable. Five best hybrids were shown in table no 3.For days to 50 % flowering, negative value of heterosis is desirable as early flowering is usually associated with early maturity. It enhances the productivity per day per unit area. Among the 21 hybrids, Eleven hybrids exhibited significant negative heterosis over mid parent. Eighteen hybrids were with significantly superior negative for heterobeltiosis. Only 15 hybrids manifested significant superiority for earliness over Jaya. The hybrids those recorded significant standard negative heterosis are *viz.*, Sahabhagi dhan x SHIATS Dhan1, MTU 1010 x BM 71, Sahabhagi dhan x NDR 359, MTU 1001 x BM 71 exhibited highest negative heterosis for days to 50 % flowering. These findings of was observed by Shankar *et al.* (2010) [5], Subbaiah *et al.* (2013) [6]. Jain *et al.* (2014) [4] Veeresha *et al.* (2015 and Sahu *et al.* (2017) [8, 7]

The negative significant heterosis for plant height is desirable because dwarf plant stature is essential to develop semi-dwarf high yielding varieties which are believed to be lodging resistant. 16 hybrids were shorter than their better parents by exhibiting significant negative heterobeltiosis. Nine hybrids showed negative heterosis over best checks over check Jaya and IR-64, respectively. Among them top three hybrids exhibiting highest magnitude of heterosis *viz.*, BPT 2411 x NDR 359, BPT 2615 x NDR 359 and MTU 1010 x SHIATS

Dhan1.These results were also reported by, Sankar *et al.* (2010), Babu *et al.* (2010), and Subbaiah *et a*l. (2013) [6] Jain *et al.* (2014) [4] and Veeresha *et al.* (2015) [8] and Huang *et al.* (2016) and Sahu *et al.* (2017) [7]

Number of panicles/ plant contributes to higher grain yield/plant, six hybrids recorded positive significant average heterosis, while two hybrids recorded positive significant heterobeltiosis. When compared to Jaya. Eight hybrids registered significant positive standard heterosis with a range varying from Standard heterosis over check IR-64 the crosses MTU1010 x BM71, MTU1010 x SHIATS Dhan1, BPT5204 x SHIATS Dhan1 and BPT 5204 x NDR 359 were the heterotic hybrids for number of panicles /plant. The similar resultswere also reported by Rosamma and Vijayakumar (2005), Sankar *et al.* (2010), Babu *et al.* (2010b), and Subbaiah *et al.* (2013) [6] Jain *et al.* (2014) [4] Veeresha *et al.* (2015) [8] and Huang *et al.* (2016) and Sahu *et al*. (2017) [7]

Panicle length with positive and significant heterosis may contribute to enhance the number of spikelets / panicle, subsequently boost the grain yield / plant. Out of 21 hybrids 17 hybrids showed the significant positive heterosis over mid parent and as many as 7 hybrids registered positive superior heterosis over better parents. The heterotic hybrids namely BPT 5204 x SHIATS Dhan1 BPT 5204 x SHIATS Dhan1were the best hybrids for panicle length. Manifested significant positive heterosis over both the standard checks. The similar results were also reported by Sankar *et al.* (2010), Babu *et al.* (2010b) and Veeresha *et al.* (2015) [8] Number of grains/panicle is the major yield attributing character, hence significant positive heterobeltiosis and standard heterosis is desirable. Sixteen hybrids recorded significant positive mid parental heterosis for total number of grains per panicle. As many as eight hybrids registered significant positive heterobeltiosis over the better parents. Seven hybrids showed significant increase in number of grains/ panicle over Jaya and IR64. Hybrids manifested significant positive standard heterosis NLR 34449 x SHIATS Dhan1, Sahabhagidhan x SHIATS Dhan1, BPT2615 x NDR359 and MTU1001 x NDR 359. These finding were also reported by Sharma *et al.* (2013) and Singh *et al.* (2013) and Veeresha *et al.* (2015) [8] and Huang *et al.* (2016).

Spikelet fertility % is one of the important traits which contribute directly to the yield enhancement. The hybrids with positive heterosis are desirable for this vital trait. Out of 21 hybrids, six hybrids *viz.*, registered significant positive standard heterosis over Jaya. The heterotic hybrids namely (BPT 2615 x BM 71). The similar results were also reported by Sharma *et al.* (2013) and Singh *et al.* (2013) and Veeresha *et al.* (2015) [8].Test weight is one of the important yield related traits. The hybrids with positive heterosis are desirable for this trait. Out of 21 hybrids eighteen hybrids were found to be superior to their mid parental values with significant positive average heterosis. While 9 hybrids recorded significantly higher grain weight over their better parents three hybrids showed higher grain weight than standard checks Jaya and IR 64, respectively MTU1010 x NDR359, NLR 34449 x BM 71 and BPT 2615 x SHIATS Dhan1 Superiority of this character was reported by Subbaiah *et al.* (2013) [6], Jain *et al.* (2014) [4], Veeresha *et al.* (2015) [8] and Huang *et al.* (2016). Heterosis for grain yield in positive direction is desirable as higher grain yield is the main objective for almost all the breeding programme. Fourteen hybrids expressed significant positive average heterosis.10 hybrids manifested significant positive heterobeltiosis. High heterosis over Jaya and IR-64 was shown by the four hybrids NLR 34449 x SHIATS Dhan1 followed by Sahabhagi dhan X SHIATS Dhan1, BPT 2615 X NDR 359 and MTU 1010 x BM 71. Negative to positive heterosis over standard check reported by Shankar *et al.* (2010) [5], Babu *et al.* (2010b) and Subbaiah *et al.* (2013) [6]. Heterosis and heterobeltiosis of both positive and negative nature was reported by Vanaja and Babu (2004), Verma *et al.* (2004) and Neelam *et al.* (2013) and Veeresha *et al.* (2015) [8] and Huang *et al.* (2016) and Sahu *et al*. (2017) [7].

Table 1: Analysis of variance for heterosis of various quantitative traits in rice.

Source of variation	df	Days to 50% Flower-ing	Plant Height (cm)	Total no of Tillers/ Plant	Number of panicles/ plant	Panicle Length (cm)	Flag Leaf Length (cm)	Flag Leaf Width (cm)	Total no of Grains/ panicle	Daysto Maturity	Spikelet Fertility (%)	Spikelet Sterility (%)	Biological yield (g)	Harvest Index (%)	Test Weight (g)	Grain Yield/ Plant (g)
Replicates	2	1.8	4.31	0.72	0.24	5.29	0.67	0.01	25.02	0.92	2.13	4.92	14.48	3.6	0.59	1.42
Treatments	30	177.01**	161.88**	8.26**	8.7**	20.66**	9.63**	0.04**	2383.4**	144.73**	60.32**	72.14**	115.15**	5.78**	17.73**	32.12**
Parents	9	279.06**	181.79**	12.95**	13.57**	27.42**	18.7**	0.02**	4192.1**	272.21**	59.69**	60.31**	156.3**	7.75**	22.94**	38.79**
Crosses	20	139.7**	147.97**	4.36**	5.82**	4.44	5.66**	0.04**	849.59**	92.98**	19.03**	31.27**	61.15**	2.66	13.22**	14.74**
Parents vs Crosses	1	4.64*	260.92**	43.92**	22.32**	284.13**	7.29	0.13**	16781.38**	32.52**	891.8**	995.84**	824.62**	50.51**	61.09***	319.64**
Error	60	1.03	6.59	0.97	1.18	3.04	2.08	0.01	67.38	1.32	6.03	7.22	17.03	1.68	0.39	2.37
Total	92	58.43	57.18	3.34	3.61	8.83	4.51	0.02	821.68	48.07	23.65	28.34	48.97	3.06	6.05	12.05

Table: 2: Estimates of heterosis, heterobeltiosis and standard heterosis for Grain Yield/ Plant (g)

Cross	Mean	Mid	Better	Jaya	IR 64	Anjali
MTU-1010 X NDR-359	32.73	5.93	5.36	5.36	-0.61	1.55
MTU-1010 XBM-71	35.30	38.34**	14.86**	13.63**	7.19	9.51*
MTU-1010 X SHIATS Dhan 1	32.73	5.82	5.14	5.36	-0.61	1.55
MTU-1001 X NDR-359	35.43	22.89**	14.06**	14.06**	7.59	9.93*
MTU-1001X BM-71	29.33	25.09**	10.28*	-5.58	-10.93**	-9.00*
MTU-1001X SHIATS Dhan 1	33.60	16.40**	7.92	8.15	2.02	4.24
Sahabhagi dhanX NDR-359	35.37	16.91**	13.84**	13.84**	7.39	9.72*
Sahabhagi dhanX BM-71	31.37	26.14**	6.57	0.97	-4.76	-2.69
Sahabhagi dhan XSHIATS Dhan 1	36.17	19.43**	16.17**	16.42**	9.82*	12.20**
BPT-5204X NDR-359	32.33	0.57	-2.71	4.08	-1.82	0.31
BPT-5204XBM-71	29.87	11.58**	-10.13*	-3.86	-9.31*	-7.34
BPT-5204XSHIATS Dhan 1	33.90	5.33	2.01	9.12*	2.94	5.17

BPT-2411XNDR-359	32.90	6.65	5.90	5.90	-0.10	2.07
BPT-2411XBM-71	32.23	26.57**	5.22	3.76	-2.13	0.00
BPT-2411XSHIATS Dhan 1	34.17	10.63**	9.74*	9.98*	3.74	6.00
BPT-2615XNDR-359	35.60	15.08**	14.58**	14.58**	8.09*	10.43*
BPT-2615XBM-71	30.27	18.46**	-1.73	-2.58	-8.10*	-6.10
BPT-2615XSHIATS Dhan 1	34.87	12.59**	11.99**	12.23**	5.87	8.17*
NLR-34449XNDR-359	30.67	1.88	-1.29	-1.29	-6.88	-4.86
NLR-34449X BM-71	32.43	31.22**	11.33*	4.40	-1.52	0.62
NLR-34449X SHIATS Dhan 1	37.46	24.31**	20.32**	20.58**	13.74**	16.22**

On the basis of *perse* performance and economic heterosis for important quantitative traits five best rice hybrids identified over the best check given in (table 3).

Table 3: Five best hybrids based on *perse* and economic heterosis (Hc) for quantitative characters in Rice

S.N.	Crosses	Characters	MEAN	Hc
1.	Days to 50% Flowering	Sahabhagi dhan x SHIATS Dhan1	79.67	-20.86**
		MTU1010 x BM71	86.00	-14.57 **
		MTU1001 x BM71	90.00	-10.60 **
		NLR34449 x NDR359	89.00	-11.59 **
		Sahahabhagi dhan x NDR359	89.00	-11.59**
2.	Plant height(cm)	BPT2411 x NDR359	100.13	-8.53**
		BPT2615 x NDR359	100.97	-7.76**
		MTU1010 x SHIATS Dhan1	106.57	-10.60**
		BPT-5204XBM71	109.71	-7.97**
		MTU1001 x SHIATS Dhan1	109.53	-8.11**
3.	Test weight(g)	MTU1010 x NDR359	24.93	19.49 **
		NLR34449 x BM71	21.57	12.72 **
		BPT2615 x SHIATS Dhan1	20.83	8.89**
		BPT2411 x BM71	21.60	12.89**
		BPT5204 x BM71	20.53	7.32
5	Grain yield/plant	NLR-34449 x SHIATS Dhan 1	37.46	13.74**
		Sahabhagi dhanxSHIATS Dhan 1	36.17	9.82*
		BPT-2615 x NDR-359	35.6	8.09*
		MTU-1001 x NDR-359	35.43	7.59
		Sahabhagi dhan x NDR-359	35.37	7.39
6.	Number of Grains/ panicle	BPT-5204 x SHIATS Dhan 1	223.33	29.92**
		BPT-5204 x NDR-359	208.5	21.29**
		BPT-2411 x SHIATS Dhan 1	207.87	20.92**
		NLR-34449 x SHIATS Dhan 1	206.27	19.99**
		MTU-1010 x BM-71	205.2	19.37**

Conclusion

Thus the findings from the present study on heterosis revealed that analysis of variance for heterosis is significant differences for all the characters studied. The differences among the parents were observed to be significant for all the characters studied while parents vs. crosses were observed to be significant for all the characters except flag leaf length and crosses were observed to be significant for all the characters except panicle length and Harvest Index.

The interaction due to lines x testers were significant for all the traits studied except panicle length. Interaction effects of Parents vs. crosses were significant for all the characters, except flag leaf length.

. High heterosis over Jaya and IR 64 was shown by the four hybrids NLR 34449 x SHIATS Dhan1 (20.58% and 13.74%) followed by Sahabhagi dhan x SHIATS Dhan1 (16.62% and 9.82%), BPT 2615 x NDR 359 (14.58% and 8.09 %) and MTU 1010 x BM 71 (13.63% and 7.19 %).these hybrids can be be used for exploitation of heterosis for yield and its components traits in rice.

References

1. Anonymous, 2013:http://www.irri.org
2. Directorate of Economics and Statistics, 2016-17.
3. FAO Food and Agriculture Organisatio, 2016.
4. Jain A. Payasi D, Reddy K, Shenoy V. 2014.
5. Shankar VG, Ansari NA, Ahamed MI, Rao PVR, 2010.
6. Subbaiah PV, Sekhar MR, Reddy KHP, Reddy NPE, 2013.
7. Sahu R, Singh SK, Singh DK, Vennela N, Prudhvi R, Reddy S, Kumar S. *et al*., 2017.
8. Veeresha BA, Hanamaratti NG, Salimath PM, 2015.