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Heterosis for yield and yield attributes in rice (*Oryza sativa* L.)

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Abstract: The present study was carried out to study the extent of heterosis, heterobeltiosis and standard heterosis for yield and yield parameters in rice. Analysis of variance indicated significant difference among the genotypes for various traits. Estimation of heterosis for various yield contributing traits indicated that out of nine crosses studied, Pusa sugandh-2 X BPT-5204 (27.93) and Pusa sugandh-2 X Kasturi (24.71) were identified as promising. These hybrids may be recommended for commercial cultivation after further evaluation.

Keywords: Hybrids, Heterosis, Rice,Yield, Yield parameters

INTRODUCTION

Rice is a staple food crop for more than fifty percent of world's population. More than 90% of the world's rice is grown and consumed in Asia. Rice accounts for 35-75% of the calories consumed by more than 3 billion Asians. In order to feed an estimated 5 billion rice consumers by 2025, rice varieties with higher yield potential and greater yield stability need to be developed (Khush, 2005). Of the various approaches contemplated to break the existing yield barriers, hybrid rice technology offers the potential strategy, as hybrid rice varieties have a yield advantage of 15-20% over the conventional high yielding varieties (Virmani, 1996). The area of around 1.8 million hectares was planted under hybrid rice in India during 2013-14 (USDA Post, 2014). It is expected that area under hybrid rice in India will increase substantially and contribute towards food security.

Significant levels of heterosis has been reported by various workers in rice (Bagheri and Jelodar, 2010; Rahimi *et al.*, 2010; Latha *et al.,* 2013). Although, research on the commercial utilization of heterosis in rice has made tremendous gains during the last 20 years, it is still in its stage of infancy as the potential yield of F_1s has not been tapped yet. The parents with optimal to intermediate genetic diversity reveals maximum heterosis (Moll and Stuber, 1974). The objective of present study was to identify highly heterotic hybrids for various yield and its attributing traits in rice.

MATERIALS AND METHODS

The present investigation was carried out during two seasons *viz., kharif*-2013 and *kharif*-2014 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (UP). The site of study is situated at 25^0 18′ N latitude and 83^0 03′ E longitudes, at an elevation of 80.71 m above mean sea level. The research material in the present study consists of three lines (Adam Cheeni, BPT-5204 and Kasturi) and three testers (Type-3, Pusa Sugandh-2 and Pusa 1121). During *kharif*-2013, all the genotypes were seeded in nursery at 3 dates, 10 days apart and transplanted in crossing blocks at 21 days after sowing. In *kharif*-2014, the seed of F_1 hybrids generated during previous season along with the parental lines and two standard checks were raised at a standard spacing of 20 x 15 cm in 5 m rows in randomized block design with three replications. The recommended package of practices was followed to raise a good crop. Observations were recorded from each replication for yield traits *viz.,* days to 50 per cent flowering, plant height, number of tillers per plant, panicle length, seeds per panicle, 100 grain weight and grain yield per plant.

Significant differences among hybrids and parents for various traits were estimated by analysis of variance. Heterosis was estimated as percentage increase or decrease of F_1 over mid parent (average heterosis), better parent (heterobeltiosis) and standard checks (PRH-10 and NDR-359) for above mentioned parameters following standard methods (Fonseca and Patterson, 1968). The *t* test was applied to determine significant difference of F_1 hybrid mean from respective better parent and standard check values using formulae as suggested by Wynne *et al.* (1970).

RESULTS AND DISCUSSION

Analysis of variance revealed that mean squares due to genotypes were significant for all the characters, indicating considerable variability among genotypes (Table 1). Heterosis was estimated as increase or

Table 1. Analysis of variance for various traits in rice.

Source of variation	Df	Days to 50% flowering	Tillers/ plant	Plant height	Panicle length	Seeds/ panicle	100 seed weight	Grain yield/ plant
Replication	2	5.352941	1.572924	50.33231	0.740243	72.41176	0.004612	3.176688
Genotype	16	506.6628**	93.27699**	1358.619**	20.34504**	6704.033**	0.368821**	215.1583**
Error	32	2.977941	3.210936	18.05458	3.206518	32.32843	0.012346	3.251467

*and ** indicate significant at P= 0.05 and P= 0.01 levels respectively

Table 2. Estimation of heterosis over mid parent, better parent and standard checks for different characters in rice.

Crosses	Days to flowering (50%)				Tillers/ plant				Plant height			
	MP	BP	MP	MP	MP	MP	SH1	SH2	MP	BP	SH1	SH2
Type-3 X Adamchini	-25.33**	-16.83**	-34.20**	-34.20**	-34.20**	-34.20**	9.72	-39.58**	-34.20**	-31.20**	3.34	14.76**
Pusa sugandh-2 X Adamchini	-23.21**	-14**	-4.40	-4.40	-4.40	-4.40	89.18**	4.17	-4.40	19.45**	30.58**	45.02**
Pusa 1121 X Adamchini	-12.28**	-3.84**	-22.35**	-22.35**	-22.35**	-22.35**	176.20**	52.08**	-22.35**	-2.89	5.99	17.72**
Type-3 X BPT-5204	-24.65**	-19.80**	-8.04**	-8.04**	-8.04**	-8.04**	13.51	-37.50**	-8.04**	29.70**	6.99	18.82**
Pusa sugandh-2 X BPT-5204	4.672**	12**	1.51	1.51	1.51	1.51	134.58**	29.17**	1.51	18.02**	-2.64	8.12*
Pusa 1121 X BPT-5204	-14.67**	-10.57**	-4.29	-4.29	-4.29	-4.29	142.15**	33.33**	-4.29	11.17*	-8.29*	1.85
Type-3 X Kasturi	21.24**	27.17**	-10.77**	-10.77**	-10.77**	-10.77**	119.45**	20.83*	-10.77**	7.39*	14.63**	27.31**
Pusa sugandh-2 X Kasturi	-16.66**	-13.04**	-11.11**	-11.11**	-11.11**	-11.11**	40.75*	-22.50*	-11.11**	-10.03**	-3.97	6.65
Pusa 1121 X Kasturi	-8.163**	-2.17	-11.96**	-11.96**	-11.96**	-11.96**	39.99*	-22.92*	-11.96**	-10.97**	-4.97	5.54

*and ** indicate significant at P= 0.05 and P= 0.01 levels, respectively; MP= mid parent heterosis, BP= heterobeltiosis, SH1= heterosis over Pusa RH-10 and SH2= heterosis over NDR-359

Table 3. Estimation of heterosis over mid parent, better parent and standard checks for different characters in rice.

Crosses	Panicle length				Seeds/ panicle				100 seed weight			
	MP	BP	SH1	SH2	MP	BP	SH1	SH2	MP	BP	SH1	SH2
Type-3 X Adamchini	-18.15**	-19.76**	-16.85**	-6.72	-18.33**	-35.22**	6.55	-14.52**	-6.89	-17.73**	-27.90**	-33.07**
Pusa sugandh-2 X Adam-chini	-6.68	-7.94	-5.84	5.62	14.90**	-7.23**	52.58**	22.40**	-10.39*	-27.56**	-21.03**	-26.69**
Pusa 1121 X Adamchini	-6.28	-11.55	-11.96*	-1.23	-19.49**	-45.44**	-10.26**	-28.01**	-19.24**	-37.02**	-24.32**	-29.75**
Type-3 X BPT-5204	12.35*	-2.08	1.49	13.85*	-7.50**	-25**	16.38**	-6.64*	-2.85	-6.46	-18.03**	-23.90**
Pusa sugandh-2 X BPT-5204	3.67	-9.13	-7.07	4.25	57.42**	30**	101.72**	61.82**	9.71*	-4.33	4.29	-3.19
Pusa 1121 X BPT-5204	-11.27	-16.97*	-26.63**	-17.70**	-29.78**	-51.67**	-25.00**	-39.84**	-6.18	-21.43**	-5.58	-12.35**
Type-3 X Kasturi	7.89	5	8.83	22.09**	18.60**	15.15**	17.93**	-5.40	-1.84	-5.83	-10.16*	-16.60**
Pusa sugandh-2 X Kasturi	-2.36	-4.35	-2.18	9.74	7.24*	6.57	9.14*	-12.45**	5.81	-0.79	8.15*	0.40
Pusa 1121 X Kasturi	2.31	-2.77	-4.62	7.00	-12.21**	-31.06**	-29.40**	-43.36**	-4.45	-14.29**	3.00	-4.38

*and ** indicate significant at P= 0.05 and P= 0.01 levels, respectively; MP= mid parent heterosis, BP= heterobeltiosis, SH1= heterosis over Pusa RH-10 and SH2= heterosis over NDR-359

Table 4. Estimation of heterosis over mid parent, better parent and standard checks for grain yield per plant in rice.

Crosses	Grain yield/ plant			
	MP	BP	SH1	SH2
Type-3 X Adamchini	62.83**	53.33**	-26.34**	-36.55**
Pusa sugandh-2 X Adamchini	99.22**	70**	2.08	-12.07*
Pusa 1121 X Adamchini	169.89**	151**	0.48	-13.45*
Type-3 X BPT-5204	24.39*	10.87	-31.95**	-41.38**
Pusa sugandh-2 X BPT-5204	144.62**	142**	48.52**	27.93**
Pusa 1121 X BPT-5204	105.71**	100**	-3.92	-17.24**
Type-3 X Kasturi	92.62**	91.59**	-6.97	-19.86**
Pusa sugandh-2 X Kasturi	166.62**	141.11**	44.78**	24.71**
Pusa 1121 X Kasturi	108.64**	73.12**	-15.93*	-27.59**

*and ** indicate significant at P= 0.05 and P= 0.01 levels, respectively; MP= mid parent heterosis, BP= heterobeltiosis, SH1= heterosis over Pusa RH-10 and SH2= heterosis over NDR-359

decrease in F_1 value over mid parent (mid parent heterosis), better parent (heterobeltiosis) and the standard commercial checks (standard heterosis) for various traits (Tables 2-4).

Early maturing hybrids are desirable in rice to fit well in multiple cropping. So, negative heterosis is desirable for days to 50 percent flowering. The hybrids Pusa sugandh-2 X Kasturi, Type-3 X BPT-5204, Type-3 X Adam chini and Pusa sugandh-2 X Adam chini showed significant negative heterosis over mid parent, better parent and standard checks. Heterosis for earliness was also reported by Eradasappa *et al.* (2007) and Sreenivas *et al.* (2014) observed three out of twenty four crosses i.e., *Warangal Samba* xEarly *Samba* (-12.10 per cent), *Samba Mahsuri* x *Kavya* (6.64 per cent) and *Samba Mahsuri* x JGL-11727 (6.38per cent) recoded significant negative heterobeltiotic effects. Heterosis in both negative and positive direction for flowering behaviour was reported by Jarwar *et al.* (2012) observed heterotic values range from -8.38 to19.38 per cent, Hussain and Sanghera (2012) reported two cross combinations out of six crosses (SKAU 7A x SR-2 and SKAU 11A x SR-2) manifested superiority for days to 50% flowering (-6.58% and -7.23%) and remaining four crosses showed positive heterosis, and Rajkumar and Ibrahim (2013) observed fifty out of one thirty six crosses exhibited negative standard heterosis. In case of plant height, negative heterosis is desirable for developing semi dwarf and dwarf varieties of rice. The hybrid Pusa 1121 X BPT-5204 showed significant negative heterosis over check Pusa RH-10. Cross combination Type-3 X Adam chini showed significant negative heterosis over mid and better parents. None of the crosses showed significant negative heterosis over check NDR -359. Heterosis in both positive and negative direction for plant height have been reported by Hussain and Sanghera (2012) observed four out of six crosses studied showed positive heterosis for plant height and remaining two crosses exhibit negative heterosis, and Rajkumar and Ibrahim (2013) reported thirty eight out of one thirty six hybrids exhibited negative standard heterosis over check .

Grain yield per plant depends on the number of tillers. So, significant positive heterosis for tillers per plant gives higher grain yield. For number of tillers per plant, hybrids Pusa 1121 X Adam chini, Pusa 1121 X BPT-5204, Pusa sugandh-2 X BPT-5204 and Type-3 X Kasturi showed significant positive heterosis over both the standard checks as well as over the respective mid and better parents. Both positive and negative heterosis for number of tillers per plant was reported by Eradasappa *et al.* (2007), Tiwari *et al.* (2011) observed value of heterosis over better parent (heterobeltiosis) varied from -34 to 39.53 and Mistry *et al.* (2015) reported value of heterosis varied from -39.86 to 215.32 per cent . For panicle length significant positive heterosis is desirable. In case of panicle length Type-3 X Kasturi and Type-3 X BPT-5204 showed positive heterosis over check NDR-359, but none of the crosses showed significant positive heterosis over another check Pusa RH-10. Rajkumar and Ibrahim (2013) reported twenty out of one thirty six hybrids exhibited significant positive standard heterosis , and Sreenivas *et al.* (2014) observed six out of twenty four crosses recorded more than 40 per cent standard heterosis for this trait.

For seeds per panicle positive heterosis is desirable. In the present study, hybrids Pusa sugandh-2 X BPT-5204 and Pusa sugandh-2 X Adam chini showed significant positive heterosis over both the checks for seeds per panicle. Crosses Pusa sugandh- 2 X BPT-5204 and Type-3 X Kasturi showed significant positive heterosis over respective better parents. These findings are in close conformity with the result of Tiwari *et al.* (2011) observed out of 60 crosses studied 3 crosses over better parent and 29 crosses over standard variety exhibited significant higher number of seeds per panicle. For 100 seed weight positive heterosis is desirable. In the present study, hybrid Pusa sugandh-2 X Kasturi showed significant positive heterosis over check Pusa RH-10 for 100 seed weight. However, none of the crosses showed significant positive heterosis over better parent and check NDR-359. Similar results were reported Abhinav *et al.* (2014) observed 21.10% and 2.27% of heterosis and heterobeltiosis for crosses IR 68902A×IR 80461-B-7-1 and IR 58025A×IR 77298-5-6-18, respectively and none of the crosses exhibited standard heterosis.

Grain yield per plant is a complex trait; its expression depends on multiple effects of several syndicated traits. Hybrids Pusa sugandh-2 X BPT-5204 and Pusa sugandh-2 X Kasturi showed significant positive heterosis over both the checks as well as over the respective better and mid parents. Pusa 1121 X Adam chini showed highest significant positive heterosis over both better and mid parent. Positive heterosis for grain yield was reported by Eradasappa *et al.* (2007), Tiwari *et al.* (2011) reported twenty out of sixty crosses exhibited standard heterosis over 30 per cent in comparision to check variety, Veeresha *et al.* (2013) observed cross combinations IR-68897A x KMR 3, IR-68897A x IR-65912-90-1-6-3-2-3R showed higher positive significant heterosis over better parent for grain yield per plant and showed significant positive heterobeltiosis for other yield contributing traits. Sunil *et al.* (2014) reported five out of thirty crosses exhibited significant and positive heterosis were *Swarna* sub 1× NDR 359, *Swarna* sub1 × *Sarjoo* 52, *Swarna* × *Sarjoo* 52, *Swarna* sub 1 × NDR 359 and Swarna × IR 64. and Mistry *et al.* (2015) observed thirty hybrids out of forty crosses showed positive heterosis whereas, twenty four hybrids registered significant positive heterobeltiosis.

The presence of high heterosis for economically important traits is not only handy for developing hybrids through exploitation of heterosis, but also helps to procure transgressive segregants for developing of superior homozygous lines.

Conclusion

The superior performance for all characters was not expressed in a single hybrid combination.

However, different cross combinations were found to be superior for different characters. A wide range of variation in the estimates of heterobeltiosis and standard heterosis in both positive and negative directions was observed for grain yield per plant. Among the nine crosses studied, Pusa sugandh-2 X BPT-5204 and Pusa sugandh-2 X Kasturi were identified as promising, as these crosses recorded highest heterosis for grain yield per plant. These hybrids may be recommended for commercial cultivation after further evaluation.

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