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STUDIES ON RELATIVE HETEROSIS AND HETEROBELTIOSIS FOR FOUR QUANTITATIVE CHARACTERS- GRAIN YIELD PER PLANT , STRAW YIELD PER PLANT , TOTAL BIOLOGICAL YIELD PER PLANT AND HARVEST INDEX IN RICE (*ORYZA SATIVA* L.)

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ABSTRACT:

Ten diverse genotypes of rice (Oryza sativa L.) were crossed in a diallel fashion to study heterosis for 12 quantitative characters. In which for grain yield per plant all the 45 hybrids exhibited positive significant heterosis over mid parent and 37 hybrids exhibited positive significant heterosis over better parent. For straw yield per plant out of 45 crosses, 44 exhibited positive significant heterosis over mid parent and 42 exhibited positive significant heterosis over better parent. For total biological yield per plant out of 45 hybrids , 43 crossses exhibited positive significant heterosis over mid parent and 31 hybrids exhibited significant positive heterosis over better parent. For harvest index out of 45 crosses 25 showed significant positive heterosis over mid parent and 20 hybrids exhibited significant positive heterosis over better parent. The estimate of relative heterosis and heterbeltiosis provide information about the type of gene action involved in expression of various quantitative characters. The information of gene action helps in the selection of breeding methods for genetic improvement of the population.

KEY WORDS: - *Better parent, Mid parent, Heterobeltiosis, Relative heterosis.*

INTRODUCTION:

Rice (*Oryza sativa* L.) is the most important staple food crop in India . In India rice has been cultivated since ancient time. There are 18 varied world species distributed mainly in Asia , Africa and America , of the two cultivated species (*Oryza sativa* and *Oryza glaberrima*) the former is cosmopolitan and the latter is confined to Africa .

The rice varieties cultivated extensively in India belong to *Oryza sativa* sub sp *indica* . A few belong to *O. sativa* sub sp *japonica* systematic breeding efforts based on genetic principles began in India in the year 1911 at the rice research station, Dhaka . In the beginning majority of varieties were developed by pure line selection.

With the advent to high yielding varieties, rice yield in the assured areas of irrigation increased and helped the country in reaching near self – sufficiency on the food front, however, these varieties are vulnerable to the ever changing diseases and pest situations. At the same time, they do not meet the quality standards of Indian consumers. Keeping these considerations in view, there is need to broaden the genetic base of our varieties to meet the diverse requirements in the country and in the export market, in case of surplus production, variation is the basis of plant breeding. Thus the success of any improvement programme will largely depend on the magnitude and range of variability in the available genetic stocks. The genetic variability and combining ability provides the basis in selecting the suitable genotypes in any breeding programme (Tiwari and Jatav 2014).

The expression of heterosis is influenced by genetic diversity of parents. Heterosis increased with genetic divergence in morphological characters and flowering time (Tiwari and Jatav 2015) and also with respect to geographical origin of parents. Maximum heterosis occurs at an optimal or intermediate level of genetic diversity. The manifestation of heterosis is associated with broad genetic base of parents. For a plant breeder, the important issue is whether the best genotypes are homozygotes or heterozygotes. If over dominance is important, the best genotypes are heterozygotes. With partial to complete dominance, the best genotype would be a homozygote. Epistasis, particularly that involves dominance effect, may also contribute to heterosis. Existence of a significant amount of dominance variance is essential for undertaking heterosis breeding programme. Dominance effects are associated with heterozygosity.

MATERIALS AND METHODS:

10 diverse parental lines viz.(i)Basmati 370 (ii) Dular(iii)Govind(iv) H.U.R.52 (v) U.P.R. 79(vi) I.R. 50(vii) Jaya (viii) Ratna (ix) Saket4(x)Pusa 150 were crossed in all possible combinations to produce 45

F1 s (excluding reciprocals) during the rainy season of year 1996 . In the next season, that is, in rainy season of 1997, F1 plants along with their parents were grown in a randomized block design with three replications at Research Farm of the Department of Agricultural Botany Kisan (Post Graduate) College Simbhaoli, Ghasziabad, UP India. F1s and parents were planted in a single and three rows respectively of 4 meter length. Obviously, there were 45 rows of F1s and 30 rows of parental lines so, there were 75 rows in each replication. All together, there are overall 225 rows in the entire experiment. The row spacing was maintained at 20 cm and plant to plant 15 cm. During transplanting single seedling were planted per hill for recording observations on 12 quantitative characters viz., days to 50 % flowering , days to maturity, plant height, number of leaves per tiller, number of spikelets per panicle, panicle length, panicle number per plant, 1000 grain weight, grain yield per plant, straw yield per plant, total biological yield per plant and harvest index.

Heterosis expressed as percentage increase or decrease in F_1 over mid (relative heterosis) and superior parent (heterobeltiosis) was calculated as suggested by Hays, Immer and Smith (1955) and Briggle (1963). The formulae used were:

$$\text{Relative heterosis} = \frac{F_1 - M.P.}{M.P} \times 100$$

$$\text{Heterobeltiosis} = \frac{F_1 - B.P.}{B.P.} \times 100$$

Testing of significance of heterosis was done using C.D. (Critical difference) values, calculated as follows:

C.D= [2MS(e) /r]½ x t (at error d.f.) (For mid parent heterosis)

C.D= [2MS(e) /r]½ x t (at error d.f.) (For better parent heterosis)

RESULTS AND DISCUSSION:

Commercial exploitation of heterosis in crop plants is regarded as one of the major break through in the field of plant breeding. The present study is an attempt to asses the possibilities of commercial exploitation of heterosis and to understand the mechanism of gene action and crosses involving high yielding, well adapted lines of rice.

The significant and non significant deviations of F_1 from mid parent indicated the presence of dominance and absence of dominance, respectively. The non significant and significant deviations of F_1 from better parent indicate the complete dominance and over dominance, respectively.

In the present study the estimates of heterosis over mid parent (relative heterosis) and over better parent (heterobeltosis) based on pooled data for 4 quantitative characters like-grain yield per plant , straw yield per plant , total biological yield per plant and harvest index are presented in Table 1. The character wise results obtained are discussed in the following text.

1. **Grain yield per plant**- The estimates of heterosis over better and mid parent ranged from -11.85 to 11.68 and 1.00 to 23.58 respectively. Out of 45 crosses 37 hybrids exhibited significant positive heterosis over better parent, whereas in case of mid parent all the 45 hybrids exhibited significant positive heterosis. The significant positive heterosis for grain yield per plant clearly indicate that maximum grain yield per plant in favour of maximum production in per unit area. The findings are in agreement with the earlier reports of Virmani et. al. (1981) and Vivekanandan et. al. (1996).

The cross combinations which exhibited significant maximum positive estimates of heterobeliosis for grain yield per plant were Basmati 370 x U.P.R 79 , Dular x Govind , Govind x U.P.R 79,H.U.R.52 x Ratna, U.P.R.79 x Jaya, I.R.50 x Ratna, Jaya x Ratna , Ratna x Saket 4.

The cross combinations which exhibited significant maximum positive estimates of relative hetrosis for grain yield per plant were Basmati 370 x Pusa 150, Dular x U.P.R 79, Govind x U.P.R.79,H.U.R.52 x Ratna,U.P.R.79 x Ratna, I.R.50 x Ratna ,Jaya x Ratna , Ratna x Saket 4 , Saket 4 x Pusa 150.

2. **Straw yield per plant**- The estimates of heterosis over better and mid parent ranged from -15.00 to 40.65 and -5.92 to 25.57, respectively. Out of 45 crosses 42 exhibited significant positive heterosis over better parent, whereas, in case of mid parent out of 45 crosses 44 exhibited significant positive heterosis. The positive significant heterosis for straw yield per plant indicate that maximum number of leaves which accumulate higher amount of photo synthetes (food material) which increase the grain weight also maximum straw yield indicate maximum number of vascular bundle in stem which provide strength to the palnt and maintain internal communication of plant for better growth. The fibdings are in agreement with the earlier reports of Ali et.al. (1995), Gopal Krashnan et. al. (1996) and Pandey (1995) .

The cross combinations which exhibited significant and maximum positive estimates of heterobeltiosis for straw yield per plant were Basmati 370 x Saket4, Dular x Saket4,Govind x Saket 4,H.U.R.52 Saket 4, U.P.R.79 x Saket 4,I.R.50 x Saket4, Jaya x Saket 4,Ratna x Saket 4, Saket 4 x Pusa 150. The above cross combinations shows that the parental line Saket 4 well contributor for production heterobeltiosis.

The cross combinations which exhibited significant and maximum positive estimates of relative heterosis for straw yield per plant were Basmati 370 x Saket 4 , Dular x Jaya, Govind x Jaya , H.U.R 52 x Saket 4, U.P.R 79 x Saket 4, I.R. 50 x Saket 4, Jaya x Saket 4, Ratna x Saket 4 ,Saket 4 x Pusa 150

3. Total Biological Yield Per Plant- The estimates of heterosis over better and mid parent ranged from - 47.71 to 43.92 and – 17.15 to 39.70, respectively. Out of 45 cross combinations 31 exhibited significant positive heterosis over better parent, whereas in case of mid parent out of 45 crosses 43 exhibited significant positive heterosis. The positive significant heterosis for total biological yield per plant indicate that the maximum dry matter produced by a plant also maximum biological yield determine the maximum economic yield and economic yield is the fraction of the biological yield which is useful for human beings. The findings are in agreement with the earlier reports of Katayam (1984), Lokaprakash et. al. (1995) , Singh et. al. (1982).

The cross combinations which exhibited maximum significant positive estimates of heterobeltiosis for total biological yield per plant were Basmati 370 x Saket 4, Dular x Saket 4, Govind x Saket 4, H.U.R.52 x Saket 4, U.P.R.79 x Saket 4, I.R.50 x Saket 4, Jaya x Saket 4, Ratna x Saket 4. The above cross combinations shows that the parental line Saket 4 well contributor for production heterobeltiosis.

The cross combinations which exhibited significant maximum positive estimates of relative heterossis for total biological yield per palnt were Basmati 370 x Saket 4, Dular x Pusa 150, Govind x U.P.R. 79, H.U.R.52 x Jaya, U.P.R.79 x Saket 4, I.R.50 x Saket 4, Jaya x Saket 4, Ratna x Saket 4, Saket 4 x Pusa 150.

4. Harvest Index – The estimates of heterosis over better and mid parent ranged from – 36.14 to 20.93 and – 17.31 to 24.86, respectively. Out of 45 crosses 20 cross exhibited significant positive heterosis over better parent , whereas in case of mid parent out of 45 crosses 25 cross exhibited significant positive heterosis. The positive significant heterosis for harvet index indicate that the maximum economic yield are obtained which is useful and beneficial fraction of biological yield for human beings. Positive and high significant heterosis for harvest index have already reported by Viramani and Subrainato (1983) and Roi and Smetanin (1984).

The cross combination which exhibited siginificant maximum positive estimates of heterobeltiosis for harvest index were Bsmati 370 x U.P.R.79, Dular x U.P.R.79,Govind x U.P.R.79, H.U.R.52 x U.P.R.79, U.P.R.79 x Jaya, I.R.50 x Jaya.

The cross combination which exhibited significant maximum positive estimates of relative heterosis for harvest index were Basmati 370 x Pusa 150, Dular x U.P.R.79, Govind x U.P.R.79, H.U.R.52 x U.P.R.79, U.P.R.79 x Ratna ,I.R. 50 x Ratna, Jaya x Ratna, Ratna x Saket 4.

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TABLE – 1 : Estimates of heterosis over mid and better parent among 4 quantitative characters Grain yield per plant, Straw yield per plant, Total biological yield and Harvest index in rice.

		CHARACTERS							
S.No.	**Crosses**	**Grain yield per plant**		**Straw yield per plant**		**Total biological yield**		**Harvest index**	
		BP	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**
1	Basmati 370 X Dular	7.48**	11.78**	21.78**	13.15**	28.26**	36.43**	- 17.77**	2.01**
2	X Govind	3.15**	5.60**	28.64**	16.84**	31.58**	34.38**	- 22.59**	- 6.19**
3	X H.U.R. 52	3.68**	6.20**	11.30**	9.70**	14.98**	27.94**	- 2.88**	3.10**
4	X U.P.R. 79	11.15**	16.58**	13.40**	9.15**	23.55**	37.23**	5.02**	17.83**
5	X I.R. 50	3.74**	9.12**	12.76**	8.38**	16.50**	29.50**	- 5.67**	7.64**
6	X Jaya	4.10**	9.00**	3.65**	8.35**	7.75**	29.35**	3.46**	8.32**
7	X Ratna	9.35**	16.90**	10.71**	7.33**	21.06**	36.73**	2.13*	18.37**
8	X Saket 4	4.44**	8.74**	33.54**	19.04**	37.90**	39.70**	- 28.94**	- 5.25**
9	X Pusa 150	4.15**	23.58**	8.15**	7.27**	- 47.71**	- 17.15**	- 3.45**	24.86**
10	Dular X Govind	11.10**	9.25**	6.83**	3.66**	17.63**	12.25**	10.76**	7.38**
11	X H.U.R. 52	11.03**	9.29**	1.70**	8.72**	12.73**	17.51**	16.16**	2.35**
12	X U.P.R. 79	11.00**	12.12**	- 3.50**	0.88**	6.50*	12.00**	20.93**	13.96**
13	X I.R. 50	6.14**	7.22**	3.76**	8.01**	9.90**	14.72**	5.82**	- 0.65
14	X Jaya	5.90**	6.50**	4.00**	17.33**	9.90**	23.33**	5.77**	- 9.15**
15	X Ratna	5.70**	8.95**	4.16**	9.40**	11.86**	19.35**	2.27*	- 1.27
16	X Saket 4	5.90**	5.90**	15.80**	9.93**	18.70**	12.32**	- 10.28**	- 6.37**
17	X Pusa 150	- 3.90**	11.18**	9.22**	16.97**	5.27	27.65**	- 12.69**	- 4.16 **
18	Govind X H.U.R. 52	1.80**	1.91**	1.20**	11.40**	3.00	13.16**	2.09*	- 8.34**
19	X U.P.R. 79	11.07**	14.05**	6.73**	14.28**	16.80**	27.68**	10.60**	7.01**
20	X I.R. 50	1.27**	4.20**	4.24**	11.66**	5.51	15.70**	1.00	- 2.10**
21	X Jaya	2.07**	4.52**	1.97**	18.47**	4.04	22.84**	1.43	- 10.11**
22	X Ratna	4.98**	10.08**	- 1.28**	7.14**	5.70	18.57**	6.99**	6.82**
23	X Saket 4	6.35**	8.20**	15.30**	12.60**	18.65**	17.65**	- 13.90**	- 6.61**
24	X Pusa 150	- 9.80**	7.17**	4.13**	15.06**	- 2.70	25.06**	- 17.58 **	- 5.67**
25	H.U.R. 52 X U.P.R. 79	8.05**	10.92**	6.50**	3.85**	15.82**	16.54**	9.99**	16.82**

26	X I.R. 50	3.53**	6.35**	6.81**	4.03**	10.34**	10.38**	- 0.92	6.41**
27	X Jaya	3.01**	5.35**	1.97**	8.27**	4.98	36.62**	6.12**	5.00**
28	X Ratna	8.18**	13.17**	4.73**	2.95**	13.91**	16.62**	5.64**	15.90**
29	X Saket 4	3.95**	5.69**	26.77**	13.87**	30.72**	19.56**	- 24.02**	- 6.31**
30	X Pusa 150	- 6.87**	9.99**	8.65**	9.37**	1.77	19.37**	- 15.66**	6.67**
31	U.P.R. 79 X I.R. 50	10.05**	10.00**	3.76**	3.63**	13.71**	13.03**	11.30**	11.83**
32	X Jaya	11.45**	10.93**	0.95**	9.90**	12.40**	20.33**	14.70**	6.75**
33	X Ratna	9.70**	11.82**	2.66**	3.50**	13.36**	15.35**	9.90**	13.33**
34	X Saket 4	9.80**	8.68**	22.48**	12.23**	32.28**	20.40**	- 10.68**	0.20
35	X Pusa 150	- 10.95**	3.05**	1.75**	5.12**	- 9.21**	7.67**	- 14.23**	1.27
36	I.R. 50 X Jaya	1.47**	1.00**	- 15.00**	- 5.92**	- 13.83**	- 5.23*	17.71**	9.27**
37	X Ratna	7.86**	10.03**	1.93**	2.93**	10.79**	13.47**	8.22**	11.15**
38	X Saket 4	4.25**	3.18**	24.50**	14.38**	28.75**	17.56**	- 21.49**	- 11.11**
39	X Pusa 150	- 11.85**	2.20**	6.25**	9.76**	- 5.30	12.26**	- 19.39**	- 4.38**
40	Jaya x Ratna	8.10**	10.75**	18.26**	10.18**	27.36**	21.43**	- 5.58**	5.79**
41	X Saket 4	3.27**	2.67**	40.65**	21.45**	43.92**	24.12**	- 36.14**	- 17.31**
42	X Pusa 150	- 6.95**	7.57**	15.73**	10.16**	8.57**	17.53**	- 21.09**	2.36**
43	Ratna x Saket 4	11.68**	8.43**	17.45**	6.33**	29.13**	15.26**	- 3.47**	3.99**
44	X Pusa 150	- 9.93**	1.94**	3.53**	6.03**	- 6.41*	8.48**	- 14.60**	- 2.53**
45	Saket 4 x Pusa 150	- 10.00**	5.12**	11.95**	25.57**	1.94	30.69**	- 21.80**	- 17.18**
	SE	0.20	0.19	0.16	0.15	2.94	2.33	1.02	0.74
	CD at 5%	0.39	0.37	0.31	0.29	5.76	4.57	1.99	1.45
	CD at 1%	0.52	0.49	0.41	0.39	7.57	6.00	2.63	1.91

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