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Research Article

STUDIES ON ECONOMIC HETEROSIS FOR GRAIN YIELD UNDER IRRIGATED AND TIMELY TRANSPLANTED CONDITION IN RICE (*ORYZA SATIVA* L)

VARTIKA B.* AND KARANWAL M.K.
Department of Genetics & Plant Breeding, G B Pant University of Agriculture and Technology, Pantnagar, 263145, India
*Corresponding Author: Email- karan.mk30@gmail.com

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Abstract: The experiment was conducted at N E Borlaug Crop Research Centre, G B Pant University of Agriculture and Technology, Pantnagar under irrigated and timely transplanted condition during *Kharif* 2015. Thirteen high yielding rice genotypes comprising 10 genotypes used as lines (including improved aromatic and non-aromatic genotypes) and 3 popular varieties were used as testers to generate 30 hybrids. All 30 F1's along with their parents were evaluated in the next year during *Kharif* 2016 to estimate the economic heterosis (standard heterosis over the check variety Pant Dhan 24) and better parent heterosis (heterobeltiosis) for six yield and its contributing traits including plant height, number of tillers per plant, number of panicles per plant, panicle length, number of filled grains per panicle and grain yield per plant. Among the parental lines, four lines namely, UPR 3037-2-2-2-1-3, UPR 2760-10-1-2, UPRI 2015-5 and Pant Dhan 26 emerged as best heterotic lines for grain yield and its main contributing traits when they were crossed with all three testers viz., HKR 47, NDR 359 and Pant Dhan 24. The estimated data on heterosis of 30 hybrids were revealed that, six crosses viz., UPR 3037-2-2-2-1-3 x HKR 47, UPR 2760-10-1-2 x HKR 47, Pant Sugandh Dhan 17 x Pant Dhan 24, UPRI 2015-5 x Pant Dhan 24, UPRI 2015-5 x NDR 359 and Pant Dhan 26 x NDR 359 exhibited highly significant and maximum economic as well as better parent heterosis for grain yield per plant and its contributing traits, indicating presence of over dominance type of gene action for these traits. Therefore, these six cross combination may be considered for selecting high yielding genotypes from segregating generations as well as development of hybrids for irrigated and timely transplanted condition.

Keywords: Economic heterosis, Heterobeltiosis, Rice, Standard heterosis

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Introduction

Rice (*Oryza sativa* L.) is one of the most important food grain crops of the world. It is staple food for nearly 70 percent of the world population. India occupies the first position in rice area and second in rice production, after china. Rice plays an important role in Indian agriculture, accounting about 43 percent of total food grain production and 46 percent of total cereal production in the country. In order to meet the domestic demand of the increasing population the present-day production of 107.40 million tonnes [1] of milled rice has to be increased to 125 million tonnes by the year 2030. Hence, it is challenging task to certifying food and nutritional security to the country. Therefore, enhancing productivity of rice through novel genetic approach like hybrid rice was felt necessary. Heterosis in rice was exploited commercially in China, India, Vietnam and the Philippines and it has been established that hybrid rice offers an economically viable option to increase cultivars yield beyond the level of semi dwarf rice cultivars. [2]. the commercial exploitation of heterosis in rice has been possible, primarily by use of WA cytoplasmic-genetic male sterility and fertility restoration system [3-4]. As we know population is increasing at an alarming rate thereby hampering the food security. This situation points towards the needs for yield improvement which can be achieved by developing high yielding varieties or hybrids. Heterosis is the superiority of F1s over its parents for one or more characters. Heterotic hybrid manifests superiority in yield, quality, disease resistance and general vigour over its parent. When superiority of hybrid is estimated over the better parent or superior parent, it is known as heterobeltiosis. Estimation of heterosis in relation to the best commercial variety is known as economic, standard or useful heterosis and is of direct practical importance for plant breeder. Generally, positive heterosis is desirable but in certain cases negative heterosis is also desirable for example, negative heterosis for days to maturity, plant height, *etc.* because it shows superiority over the parents. Due to increasing the population exponentially decreasing cultivable land day by day alarming the food security of country, therefore to achieve self-sufficiency it is dire need to develop the new genotypes and hybrids having batter yield potential per unit area and better-quality parameters. This could be achieved only by exploring maximum genetic potential from available germplasm lines to producing high yielder genotypes in F1 hybrids and their segregating generations. Magnitude of heterosis provide basis for genetic diversity and choice of desirable parent. Therefore, present study was conducted to estimate the level of better parent heterosis and economic heterosis for grain yield and its related traits among 30 hybrids of 13 genetically diverse rice genotypes. This investigation would be helpful to the plant breeder to evaluate the suitable parents for making the crosses and identification of new yield potential genotypes for irrigated and timely transplanted condition, which will increase both production and productivity of the rice.

Materials and Methods

The present study was conducted under irrigated and timely transplanted condition of Tarai region of Uttarakhand. Better parent and economic heterosis for yield and its contributing traits were estimated in L x T mating design involving ten genetically diverse rice genotypic lines (PR113, Pant Sugandh Dhan 17, UPR 3912-21-2-1, UPR 3654-5-1-2, UPRI 2015-2, UPR 3037-2-2-1-3, UPR 3905-22-2-2-1, UPR 2760-10-1-2, UPR 2015-5 and Pant Dhan 26) and three genetically diverse and high yielder testers *viz*., HKR 47, Pant Dhan 24 and NDR 359. All thirteen parental genotypes and their 30 F1's grown in nursery and then 25 days seedlings were transplanted in a randomized complete block design with three replications during *Kharif* 2016 at N E Borlaug Crop Research Centre, Table-1 *Mean squares from Line x Tester analysis for seed yield and its contributing characters in rice (Oryza sativa L.) under timely transplanted condition.*

Source of variation	DF	Mean Squares					
		Plant height (cm)	No. of tillers/ plant	No. of panicles/ plant	Panicle length (cm)	No. of filled grains/panicle	Grain yield/ plant (g)
Replication	2	0.216	5.83	2.49	1.71	90.23	1.32
Parents	12	6.73**	382.74**	1.91	3.06**	367.58**	8.67**
Male	2	10.12**	344.60**	2.06	2.11	608.12**	6.32**
Female	9	1.92	48.02**	11.37**	53.22**	21.33**	19.80**
Male *vs* Female	18	3.08**	128.50**	8.71**	105.03**	390.13**	3.35*
Hybrids	29	87.56**	182.66**	16.93**	93.66**	82.64**	88.25**
Parents *vs* Hybrids	1	148.43**	9.78**	135.08**	214.50**	860.11**	412.68**
Error	62	5.08	26.56	2.78	3.73	93.26	5.11

*, ***Significant at 5% and 1% level of significance, respectively*

Table-2 *Estimated heterosis over the better parent and standard check for grain yield and its contributing characters in rice (Oryza sativa L.) under timely transplanted condition*

SN	Crosses		Plant height (cm)	Number of tillers per plant	Number of panicles per plant	Panicle length (cm)	Number of filled grains per panicle	Grain yield per plant (g)
1.	UPR-3905-22-2-2-1×HKR 47	BH	-5.60*	8.00	4.54	8.37	-1.78	-12.83
		SH	-17.65**	-21.35**	-30.99**	-33.75**	-43.00**	-66.05**
2.	Pant Sugandh Dhan 17× HKR47	BH	-4.87	-13.63	5.55	8.85	8.00	-8.40
		SH	-19.4**	-44.66**	-42.92**	-8.57	-16.06**	-61.84**
3.	PR113×HKR47	BH	5.49*	11.11	-13.33	-11.44*	1.78	-8.40
		SH	-3.40	-41.74**	-61.00**	-17.08**	-11.39**	-68.03**
4.	UPR3037-2-2-1-3×HKR47	BH	8.45**	30.00 *	17.14**	4.01	2.60	18.24**
		SH	6.08**	59.23**	43.76**	9.59*	10.52**	23.78**
5.	UPRI 2015-5×HKR47	BH	2.02	28.00**	10.39	-5.34	-6.52	5.08
		SH	-6.91**	-6.79	-18.90**	-19.52**	-10.81*	-28.35**
6.	UPR3912-21-2-1×HKR47	BH	-15.89**	29.63**	7.69	9.80*	10.52**	8.81**
		SH	-2.31	1.94	-15.79*	-1.39	8.80*	-10.13**
7.	UPR 3654-5-1-2×HKR47	BH	5.00*	25.00**	11.53	-15.95**	3.70	-6.89
		SH	-5.62**	1.94	-12.88*	-30.95**	-27.46**	-43.60**
8.	UPRI 2015-2×HKR47	BH	3.34	26.66**	17.24*	14.70*	2.15	-9.98*
		SH	-4.40*	10.68**	2.00	-12.51**	-26.42**	-35.86**
9.	UPR 2760-10-1-2×HKR 47	BH	-6.70**	18.91**	19.66**	13.43*	1.98	11.58**
		SH	-8.28**	-12.62	15.99*	19.23**	23.31**	16.19**
10.	Pant Dhan 26×HKR47	BH	3.27	-20.00	-22.22	8.23	2.27	-10.09*
		SH	-6.98**	-53.39**	8.03	-26.12**	-30.05**	-64.06**
11.	UPR-3905-22-2-2-1×Pant Dhan 24	BH	2.36	0.50	13.33	-1.84	-3.57	10.03**
		SH	2.83	-47.57**	-48.68**	-29.85**	-19.08**	-58.61**
12.	Pant Sugandh Dhan 17×Pant Dhand 24	BH	-16.89**	37.50*	35.71**	-11.67**	9.00**	6.39
		SH	-5.44**	35.92**	42.56**	5.41	12.95**	22.15**
13.	PR113×Pant Dhan 24	BH	8.20**	35.29*	11.76	-14.02**	4.61	-5.96
		SH	5.83**	-33.00**	-38.46**	-16.58**	5.69	-39.11**
14.	UPR3037-2-2-1-3×Pant Dhan 24	BH	3.18	-27.27*	-23.81*	8.23	4.18	5.34
		SH	20.66**	-53.39**	-52.00**	4.94	16.06**	-32.80**
15.	UPRI 2015-5×Pant Dhan 24	BH	2.54	28.00**	27.27**	1.78	13.57**	23.89**
		SH	1.05	47.57**	43.55**	12.91**	19.18**	21.64**
16.	UPR3912-21-2-1×Pant Dhan 24	BH	3.98	11.76	12.90	7.04	-4.95	3.03
		SH	-1.23	10.68	5.00	-2.99	0.51	0.08
17.	UPR 3654-5-1-2×Pant Dhan 24	BH	2.97	-9.09	5.62*	-1.85	3.33	3.37
		SH	15.00**	-12.62	-18.90**	-0.127	12.43**	3.032
18.	UPRI 2015-2×Pant Dhan 24	BH	3.10	-11.62	-14.63**	-16.44**	3.82	16.10**
		SH	-2.92	10.68	5.01	-18.97**	-1.55	14.72**
19.	UPR 2760-10-1-2×Pant Dhan 24	BH	3.94	33.30**	31.81**	-14.29**	1.61	5.52
		SH	-3.01	-6.79	-12.71*	-20.28**	-2.07	-25.224**
20.	Pant Dhan 26×Pant Dhan 24	BH	2.30	0.80	11.11	3.32	5.38	5.12
		SH	7.86**	-35.92**	-39.92**	5.51	5.69	-21.51**
21.	UPR-3905-22-2-2-1×NDR 359	BH	-1.88	-26.66**	-16.00	3.85	3.84	-5.41
		SH	-11.19**	-30.57**	-36.55**	-7.25	-2.07	-38.74**
22.	Pant Sugandh Dhan 17×NDR 359	BH	-1.57	-9.09	-12.90	11.15*	5.02	-8.22*
		SH	-8.75**	-12.62	-18.43**	-7.30	-2.59	-22.20**
23.	PR113×NDR 359	BH	-2.43	28.00**	21.73*	15.99*	-1.50	-5.40
		SH	-21.66**	-6.79	-15.09*	-21.60**	-32.12**	-48.92**
24.	UPR3037-2-2-1-3×NDR 359	BH	5.85*	31.81**	35.00**	3.14	-2.56	9.85*
		SH	-5.74**	-15.53**	-18.69**	-4.38	-1.55	-27.17**
25.	UPRI 2015-5×NDR 359	BH	-13.15	8.57	6.06	3.77	17.36**	6.38*
		SH	-15.67**	28.68**	15.00**	14.57**	21.76**	15.10**
26.	UPR3912-21-2-1× NDR 359	BH	7.42**	-9.37	-12.90	3.36	3.47	-6.58
		SH	2.83	-15.53*	-18.45**	-32.62**	-38.34**	-49.52**
27.	UPR 3654-5-1-2× NDR 359	BH	6.10**	3.21	9.35*	12.37**	-4.44	5.78
		SH	1.46	6.50	5.00	3.12	8.59	4.34
28.	UPRI 2015-2× NDR 359	BH	3.34	-20.00	0.50	-3.00	4.87	15.71**
		SH	-16.89**	-53.39**	-52.00**	-31.13**	-33.16**	-62.91**
29.	UPR 2760-10-1-2×NDR 359	BH	6.80**	33.33*	37.50**	0.80	6.14	-16.79**
		SH	0.90	-30.09**	-33.43**	-30.64**	-37.30**	-69.60**
30.	Pant Dhan 26× NDR 359	BH	6.16*	11.36*	9.75	9.37	4.73	6.84*
		SH	-12.06**	42.72**	35.04**	16.29**	19.68**	18 .44**

BH= Batter parent Heterosis, SH= Standard Heterosis (Economic Heterosis)

G B Pant University of Agriculture and Technology, Pantnagar under irrigated and timely transplanted condition. Each plot comprises of a single three meters log row, the rows were spaced 30 cm. Apart and plant to plant distance at 15 cm. The experiment was conducted under irrigated timely transplanted condition. Observations were recorded on five randomly competitive plants from each row. The better parent and economic heterosis for all yield and its related traits were estimated as suggested by [5]. The t-test was calculated to determine whether F1 hybrid mean were statistically significant or not from better parent and standard parental values compared to t tab values at 0.05 and 0.01 levels as discusses by [6]. Deviation of F1 from its better parent values or either of the parental values was interpreted by [7] depicting type of gene action operating from controlling the trait.

Standard Heterosis = {F1ij- SP ij)/SP ij)} x 100

Heterobeltiosis = {F1ij- BP ij)/BP ij)} x 100

t cal for standard heterosis

"t" = (F1 ij-SPij)_/V3/8EMS

t cal for heterobeltiosis

"t" = (F1 ij-BPij)_/V1/2EMS

F1 ij= the mean of the ijth F1 crosses, SP ij = the standard parent value for the ijth, BPij= value of better parent out of the i and jth parent, i= the female parent and j= the male parent.

Results and Discussion

The genotypic mean squares indicating highly significant differences among parental genotypes and their hybrids for all the characters studied [Table-1].The per se performance of parents depicted that, Pant Dhan 24, Pant Dhan 26, NDR 359 and UPRI 2015-5, HKR 47 and Pant Sugandh Dhan 17 were found good yielder under irrigated and timely sown environment. Their crosses *viz*., UPR 3037-2-2-1-3 x HKR 47, Pant Sugandh Dhan 17 x Pant Dhan 24, UPRI 2015-5 x Pant Dhan 24, Pant Dhan 26 x NDR 359, UPR 2760-10-1-2 x HKR 47 and UPRI 2015-5 x NDR 359 also exhibited excellent significant positive heterosis under same environment for grain yield per plant and many other directly related traits [Table-2].

The varieties must stand without lodging under both high fertility and water lodged condition and must be short and stiff strewed which will increase the time period for which the plant will stand without lodging. Thus, negative heterosis for plat height is desirable [8]. Highly significant and negative economic heterosis for plant height were exhibited by the cross PR 113 x NDR 359 followed by Pant Sugandh Dhan 17 x HKR 47, UPR 3905-2-2-1-3 x HKR 47 and UPRI 2015-5 x NDR 359. The cross UPRI 2015-5 x NDR 359 showed significant negative standard heterosis while, heterobeltiosis was expressed in opposite direction in this case, indicating the fact that, partial dominant type of gene action was being operated in this cross [Table-2]. Similar findings on negative heterosis for plant height were reported by earlier researchers [9]. For getting high yield a greater number of tillers and panicle per plant are desirable. [Table-2] revealed that, cross UPR 3037-2-2-1-3 x HKR 47 followed by UPRI 2015-5 x Pant Dhan 24, Pant Dhan 26 x NDR 359 and Pant Sugandh Dhan 17 x Pant Dhan 24 showed positive significant economic heterosis for number of tillers per plant. However, the cross-pant Sugandh Dhan 17 x Pant Dhan 24 expressed highest heterobeltiosis followed by PR113 x ant Dhan 24, UPR 2760-10-1-2 x NDR 359 and UPR 2760-10-1-2 x Pant Dhan 24 indicating over dominance type of gene action operating in these crosses [10]. More the number of panicles per plant would give higher yield. Therefore, positive significant heterosis for this trait is desirable in rice. The highest significant positive economic and better parent heterosis was exhibited by the cross UPR 3037-2-2-3 x HKR 47 followed by UPRI 2015-5 x Pant Dhan 24, Pant Sugandh Dhan 17 x Pant Dhan 24, Pant Dhan 26 x NDR 359. Similar results were also reported earlier in rice [11]. Number of filled grains per panicle and panicle length are important traits of grain yield, these traits contributes towards productivity and should be taken in to consideration during selection. Crosses UPR 2760-10-1-2 x HKR 47 exhibited highest significant and positive economic heterosis for these characters followed by UPRI 2015-5 x NDR 359, Pant Dhan 26 x NDR 359 and UPRI 2015-5 x Pant Dhan 24. Earlier positive heterosis for panicle length and number of filled grains per panicle were also reported in rice [12]. During selection in the segregating generations grain yield per plant receive the maximum attention of plant breeder. Hence positive heterosis for this character is desirable. [Table-2] indicate that under irrigated and timely sown condition, out of 30 only 6 crosses *viz*., UPR 3057-2-2-1-3 x HKR 47, Pant Dhan 17 x Pant Dhan 24, UPRI 2015-5 x Pant Dhan 24, Pant Dhan 26 x NDR 359, UPR 2760-10-1-2 x HKR 47 and UPRI 2015-5 x NDR 359 expresses highest positive significant economic heterosis and heterobeltiosis for grain yield [10].

Conclusion

On the basis of present investigation, it is concluded that, the parents namely, HKR 47, Pant Dhan 24, Pant Dhan 26, NDR 359, Pant Sugandh Dhan 17, UPR 3037-2-2-1-3 and UPRI 2015-5 emerged as good combiner for grain yield per plant under irrigated and timely sown environment. The six crosses *viz*., UPR 3057-2-2-1-3 x HKR 47, Pant Dhan 17 x Pant Dhan 24, UPRI 2015-5 x Pant Dhan 24, Pant Dhan 26 x NDR 359, UPR 2760-10-1-2 x HKR 47 and UPRI 2015-5 x NDR 359 should be given due consideration to develop high yield potential varieties from selection in late segregating generations or through hybridization programme for the irrigated and timely sown condition.

Application of Research: The findings of present investigation are to be helpful to the plant breeders/ researchers to select high yield potential genotypes of rice for irrigated and timely sown area which will help to sustain the food security of the country.

Research Category: Economic heterosis

Abbreviations: BH= Batter parent Heterosis, SH= Standard Heterosis (Economic Heterosis), DF= degree of freedom

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