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EFFECTS OF HETEROSIS FOR YIELD AND YIELD CONTRIBUTING CHARACTERS IN RICE (*ORYZA SATIVA* L.) UNDER SODIC SOIL

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ABSTRACT

The present study "effects of heterosis for yield and yield contributing characters in rice (*Oryza sativa* L.)" was conducted to estimate under sodic soil. Heterosis estimates were worked out through Line × Tester analysis of 45 hybrids developed by crossing fifteen lines with three testers to know the genetic architecture of 12 physio-morphological traits under sodic environment. An outset on perusal of data for hybrids based on the cross combinations Jhona x Pusa 169 resulted from crossing between parents having high genetic distance showed high positive significant standard heterosis for seed yield. However, the crosses *viz.,* Shriram 434 x PB 1, Halchal x IR 24, Magic x Pusa 169 and Super Moti x Pusa 169, gives sparingly high significant negative standard heterosis for seed yield although their parents having high genetic distance. These cross combinations merit consideration for extensive testing across space and time in the target environment to verify their suitability for commercial exploitation. The reason for this could have been linkage of alleles in repulsive phase for biomass and yield. As there was dominance gene action involved, inter se matings followed by recombination breeding might be advocated for improvement of yield under sodicity.

Key words : *Heterosis, parents and line × tester analysis.*

Rice is the most important staple food for 40 percent of the world population. It is grown under a wide range of agro climatic conditions. A total of 800 million hectares of land throughout the world are salt affected either by salinity (397 million ha) or the associated condition of sodicity (434 million ha) In India alone, salt-affected soils have been estimated to occur in 8.6 million ha, of which about 3.0 million ha are coastal saline. Rice breeders are increasingly challenged in the new century to meet the rapidly growing food demands of an increasing human population. To increase the rice production there is the need to increase the rice growing areas. A hybrid is commercially valuable only when it exhibits significantly high standard heterosis over the best locally adopted variety or hybrid. Apart from high vigour and yield, the hybrids can be a potential genetic source for better root system with higher efficiency to absorb moisture effectively for tolerating drought condition. Existence of heterosis for drought tolerant traits will be a boon to drought tolerance breeding since most of the hybrids developed so far lack of tolerance to abiotic and biotic stresses. Hence the situation is arising to extend the rice cultivation into marginal lands where salinity levels in soils are above thresholds affecting rice growth and yield. Recently, the salt affected area is increasing due to the irrigation with salt affected water, high intensity of cropping pattern and more application of chemical fertilizers. Unfortunately, rice is one of the most saltsensitive cereal crops. Growth and yield components of rice are severely affected by salinity (1). Hence there is an urgent need to develop the salt tolerant varieties in rice. With these points in view, the present investigation was carried out to select superior hybrids by studying their per se performance and standard heterosis under sodic soil.

MATERIALS AND METHODS

The present investigation was conducted at Farmer Field of village Amwa Bhaluhi of Bhathat Block District: Gorakhpur, where the soil is found to be sodic in nature. The crosses were made during Kharif, 2015 and the hybrids along with parental lines and checks were evaluated during Kharif, 2015. Lines were used as female whereas testers as male parents. The experiment was laid out in randomized complete block design with three replications adopting a recommended spacing of 20 x 15 cm in field during 2015. Recommended package of practices were followed to establish the crop. Ten plants were selected randomly from each entry in each replication to record data on 12 traits viz., Days to maturity, Plant height (cm), Panicle bearing tillers per plant, Panicle length (cm), Spikelets per panicle, Spikelet fertility (%), 1000-grain weight (g), Biological yield per plant (g), Harvest-index (%), L/B ratio, and Grain yield per plant (g). The magnitude of heterosis in F1s was estimated in relation to better parent and the checks as percent increase or decrease of F1 over better parent (Heterobeltiosis) and the checks (standard / useful / commercial heterosis) by following the procedures out-lined by (2).

(i) Heterobeltiosis = $\frac{F_1 - BP}{BP}$ 100

Where,

F_1 = Mean performance of single cross

BP = Mean performance of better parent

(ii) Standard heterosis = $\frac{(F_1 - SC)}{SC}$ 100

Where,

SC = Mean performance of the standard check

Further, the significance was tested using t-test suggested by Snedecor and Cochran (1967) as follows :

Heterobeltiosis 't cal' = $\frac{(F_1 - BP)}{\sqrt{2EMS / r}}$

Standard heterosis 't cal' = $\frac{(F_1 - MP)}{\sqrt{3EMS / 2r}}$

Standard heterosis 't cal' = $\frac{(F_1 - SC)}{\sqrt{3EMS / r}}$

Where,

EMS = Error mean squares in the ANOVA table

r = Number of replications

Calculated 't' values were compared with table value of 't' at the respective error degrees of freedom.

RESULTS AND DISCUSSION

Out of 45 crosses 23 crosses over better parent and 17 crosses over standard variety exhibited significant positive heterosis during 2015. The cross RHR27 x PB-1 exhibited maximum heterosis over better parent (18.61%) and over standard variety (12.97%), respectively during 2015. The estimates of heterosis ranged from -14.17 per cent (SHRIRAM453 xPUSA 169) to 14.26% (RHR27 x IR24) and from -17.18% (MAGIC x PUSA 169) to 11% (SUPER MOTI x IR24) over better parent and standard variety respectively during 2015. Out of 45 crosses 15 crosses over better parent and 21 crosses over standard parents showed significant negative heterosis during 2015 for days to maturity. Negative heterosis for early maturing was also reported by (3) in rice.

In plant height ranged from -12.32 (MAGIC x PB-1) to 22.26 (SARJU 52 x IR24) per cent over better parent and -6.91 (SARJU 52 x PB-1) to 23.72 (SHRIRAM432 x PUSA 169) standard variety during 2015. Among 45 crosses studied significant negative heterosis was observed in 10 crosses over better parent and 2 crosses over standard variety in for plant height during 2015. Negative heterosis for plant height is desirable for breeding short statured hybrids and varieties. None of the hybrids manifested significantly negative mid-parent and high-parent heterosis for plant height (4). This was in agreement with earlier reports (5).

Out of 45 hybrids only two hybrids *i.e.,* JHONA 349 x IR24 and KUBER x IR24 over better parent and only cross KUBER x IR24 over standard variety showed significant positive heterosis in 2015 on ear bearing tillers per plant. The extent of heterosis ranged from 22.81 (SHRIRAM453 x PB-1) to 7.46 (JHONA 349 x IR24) per cent over better parent and from 36.38 (SHRIRAM453 x PB-1) to 5.50 (KUBER x PB-1) per cent over standard variety in year 2015. Similar results were also reported by earlier workers (6).

Three crosses over better parent and 26 crosses over standard variety exhibited significant positive heterosis and none of the cross exhibited significant negative over standard variety for panicle length and the cross SHRIRAM434 x IR24 exhibited maximum heterosis (76.55%) and 112.46%) over better parent and standard variety, respectively in year 2015. These findings are close conformity with the findings of (6, 7). However, negative heterosis found for panicle length.

The estimates of heterosis ranged from -27.92 (SUPER MOTI x PUSA 169) to 8.98 (SHRIRAM RESHMA x PB-1) per cent over better parent and from -13.19 (SUMO x PUSA 169) to 23.67 (KUBER x IR24) per cent over standard variety for spikelets per panicle. Among 45 crosses studied, two crosses over better parent and 22 crosses over standard variety exhibited significant positive heterosis in year 2015. Similar results were also reported by earlier workers (6, 8).

On the extents of heterosis for spikelet fertility per cent over better parent ranged from -24.19 (SUPER MOTI x PUSA 169) to 21.87 (MAGIC x PUSA 169) and from -22.64 (SUPER MOTI x PUSA 169) to 11.87 (SHRIRAM432 x IR24) per cent during 2015. However, the extent of heterosis over standard variety was ranged from -4.86 (SUPER MOTI x IR24) to 66.99 (SHRIRAM434 x PUSA 169) per cent. Out of 45 crosses, only 5 crosses over better parent and 39 crosses over standard variety showed significant positive heterosis during 2015. Thirty crosses over better parent showed significant negative heterosis while, none of the cross showed significant negative heterosis over standard variety during year 2015. (9) found high heterosis for grain yield and its components in rice. Similar results were also reported by earlier workers (6, 7).

The heterosis values for test weight over better parent ranged from -17.83 (SUPER MOTI x PUSA 169) to 13.70 (SHRIRAM432 x IR24) and from -19.05 (SHRIRAM453 x IR24) to 17.35 (KUBER x IR24) per cent while over standard variety in ranged from -16.94 (SUMO x PUSA 169) to 15.77 (VIDYA295 x PB-1) and from -17.97 (SUMO x IR24) to 18.07 (VIDYA295 x PB-1) per cent during 2015. Among 45 crosses studied, only 8 crosses over better parent and 7 crosses over standard variety exhibited significant positive heterosis for this

Table-1 : Heterosis over better parent and Standard variety 2015.

Crosses	Days to 50% flowering		Days to Maturity		Plant height		EBT	
	BP	SV	BP	SV	BP	SV	BP	SV
SARJU 52 X PUSA 169	-3.41	-5.31*	-3.23	-6.69**	10.21*	1.33	-4.67	-26.81**
SARJU 52 X PB-1	-3.04	-4.94*	-4.25	-7.68**	1.25	-6.91**	-15.66**	-15.66**
SARJU 52 X IR 24	14.81**	12.56**	-3.8	-7.25**	22.26**	12.41**	1.69	-5.64*
NAGINA X PUSA 169	5.44*	3.77	1.28	-1.23	9.97**	19.68**	-1.01	-14.17**
NAGINA X PB-1	6.85**	5.16*	1.88	-0.65	3.62	12.76**	-1.04	-1.04
NAGINA X IR 24	-2.81	-4.35	-1.86	-4.3	-2.21	6.42*	-8.11**	-14.74**
JHONA X PUSA 169	5.64*	4.83*	-0.05	-0.7	9.98**	19.68**	-4.49	-10.49**
JHONA X PB-1	-6.79**	-6.79**	-8.70**	-9.29**	-1.86	-1.86	-9.92**	-9.92**
JHONA X IR 24	9.35**	9.84**	5.39*	4.71	8.88**	18.48**	7.46**	0.72
MAGIC X PUSA 169	-10.80**	-15.75**	-14.77**	-17.18**	-8.29**	-1.06	-21.57**	-25.01**
MAGIC X PB-1	-7.36**	-12.5	-11.73**	-14.23**	-12.32**	-5.42*	-11.98**	-11.98**
MAGIC X IR 24	-8.04**	-13.14**	-12.03**	-14.52**	-9.88**	-2.78	-13.29**	-17.10**
KUBER X PUSA 169	-8.40**	-9.10**	-10.91**	-10.90**	-10.77**	4.38	-18.08**	-23.34**
KUBER X PB-1	10.51**	10.51**	6.41*	6.41*	17.89**	17.89**	5.50*	5.50*
KUBER X IR 24	5.10**	8.01**	1.58	2.36	6.88**	18.20**	4.56	-2.15
SUMO X PUSA 169	-3.45**	-7.22**	-8.30**	-11.62**	-3.35	13.07**	0.95	-22.49**
SUMO X PB-1	2.03**	-1.95	-2.19	-5.74*	10.38**	10.38**	-6.80**	-6.80**
SUMO X IR 24	9.78**	5.50*	6.01*	2.17	10.86**	22.61**	2.35	-5.03*
SHRIRAM RESHMA X PUSA 169	3.78**	2.98	-1.55	-2.42	10.48**	14.92**	-3.29	-15.41**
SHRIRAM RESHMA X PB-1	2.37**	2.37	-1.56	-2.43	1.01	5.07*	-4.39	-4.39
SHRIRAM RESHMA X IR 24	-3.95**	-3.25	-2.68	-3.54	-0.96	3.01	-7.73**	-14.38**
SHRIRAM 432 X PUSA 169	6.15**	5.04*	3.70*	2.33	8.27**	23.72**	0.05	-13.47**
SHRIRAM 432 X PB-1	7.57**	6.44**	5.7	4.31	15.71**	15.71**	-0.23	-0.23
SHRIRAM 432 X IR 24	-1.04*	-2.08	-3.49	-4.76	-3.58	10.19**	-6.30*	-13.05**
SHRIRAM 434 X PUSA 169	6.88**	6.06**	2.28	2.3	11.69**	20.13**	3.99	-17.01**
SHRIRAM 434 X PB-1	-6.59**	-6.59**	-1.45	-1.45	-2.45	-2.45	-16.39**	-16.39**
SHRIRAM 434 X IR 24	13.15**	14.15**	-2.76	1.09	14.59**	23.26**	4.16	-3.35
SHRIRAM 453 X PUSA 169	-10.24**	-10.92**	-14.17**	-14.16**	-8.95**	1.82	-17.14**	-36.38**
SHRIRAM 453 X PB-1	-6.52**	-6.52**	-11.14**	-11.14**	-1.5	-1.5	-22.81**	-22.81**
SHRIRAM 453 X IR 24	-9.89**	-7.22**	-13.16**	-11.45**	-8.49**	1.2	-22.11**	-27.73**
VIDYA 295 X PUSA 169	-8.65**	-9.35**	-11.56**	-12.42**	-4.15	3.46	-15.03**	-34.76
VIDYA 295 X PB-1	13.00**	13.00**	9.54**	8.47**	18.52**	18.52**	-5.87*	-5.87*
VIDYA 295 X IR 24	5.54**	5.54*	-0.58	-1.56	6.29**	14.73**	-10.68**	-17.11**
RHR 27 X PUSA 169	-6.07**	-10.54**	-9.09**	-12.81**	-5.69*	7.30**	-10.30**	-31.13**
RHR 27 X PB-1	-1.60**	-6.28**	-2.97	-6.94**	3.68	3.68	-16.99**	-16.99**
RHR 27 X IR 24	18.61**	12.97**	14.62**	9.93**	16.65**	29.01**	1.81	-5.53*
VEDA X PUSA 169	11.45**	2.1	5.62*	0.53	13.19**	20.80**	3.74	-15.18**
VEDA X PB-1	18.17**	8.26**	10.73**	5.40*	17.83**	17.83**	2.69	2.69
VEDA X IR 24	1.94**	-6.61**	-2.71	-7.40**	-1.24	5.40*	-9.71**	-16.22**
HALCHAL X PUSA 169	-9.70**	-12.93**	-12.20**	-15.71**	-8.40**	3.47	-11.62**	-31.18**
HALCHAL X PB-1	-6.30**	-9.64**	-10.17**	-13.76**	-0.97	-0.97	-18.18**	-18.18**
HALCHAL X IR 24	-11.09**	-14.27**	-13.56**	-17.02**	-12.07**	-2.75	-20.92**	-26.62**
SUPER MOTI X PUSA 169	-7.85**	-8.55**	-12.23**	-12.21**	-5.39*	4.74	-12.98**	-33.19**
SUPER MOTI X PB-1	15.00**	15.00**	10.99**	10.99**	21.15**	21.15**	-3.06	-3.06
SUPER MOTI X IR 24	13.42*	13.7**	9.80**	11.00**	15.30**	18.65**	-3.6	3.7
No. of crosses with (+) value	5	39	8	7	13	14	17	17
No. of crosses with (-) value	30	0	20	17	21	15	19	21
Range of heterosis	-24.19 to 21.87	-4.86 to 66.99	-17.83 to 13.70	-16.94 to 15.77	-19.23 to 15.19	-16.49 to 16.62	-17.94 to 15.19	-16.49 to 16.62

Table-1 Contd.......

Table-1 Contd......

Crosses	Days to 50% flowering		Days to Maturity		Plant height		EBT	
	BP	SV	BP	SV	BP	SV	BP	SV
SARJU 52 X PUSA 169	-9.65**	5.8	-19.18**	-4.56	-12.45**	34.86**	-10.87**	-15.99**
SARJU 52 X PB-1	-8.50**	-3.35	-2.12	15.59**	-8.08**	33.89**	4.88	4.88
SARJU 52 X IR 24	-1.42	18.63**	-2.46	15.19**	-5.24*	38.02**	1.21	0.83
NAGINA X PUSA 169	-0.45	16.57**	-14.84**	-0.89	-2.94	43.30**	-6.96*	-12.30**
NAGINA X PB-1	-5.05	10.18**	-10.76**	3.87	-16.13**	23.82**	-4.81	-4.81
NAGINA X IR 24	-6.70**	12.28**	0.2	16.62**	-4.91	40.39**	1.08	0.7
JHONA X PUSA 169	-1.46	15.39**	-10.94**	-7.51**	0.21	54.36**	1.23	-4.58
JHONA X PB-1	-13.65**	-3.82	-9.40**	-9.40**	-14.00**	25.31**	-2.58	-2.58
JHONA X IR 24	-0.83	19.34**	-16.58**	-6.34*	-14.28**	24.90**	-9.10**	-9.44**
MAGIC X PUSA 169	-17.06**	-0.36	-4.98*	16.78**	21.87**	44.47**	4.03	-1.94
MAGIC X PB-1	-20.29**	-4.24	-4.78*	17.02**	-1.37	16.92**	2.06	2.06
MAGIC X IR 24	-15.07**	2.2	-10.06**	10.53*	-3.53	14.36**	-7.32*	-7.66**
KUBER X PUSA 169	-15.35**	-0.87	-6.81**	16.99**	5.10*	61.89**	4.55	-1.45
haKUBER X PB-1	-0.28	13.12**	-19.15**	1.49	-22.79**	16.91**	-10.87**	-10.87**
KUBER X IR 24	-2.87	16.89**	-1.49	23.67**	-0.64	50.45**	7.54*	7.14*
SUMO X PUSA 169	-12.50**	8.50**	-13.53**	-13.19**	-16.46**	28.69**	-11.89**	-16.94**
SUMO X PB-1	-13.29**	7.52*	-12.17**	-11.83**	-20.77**	9.68*	-10.53**	-10.53**
SUMO X IR 24	0.49	24.61**	-8.90**	-8.55**	-16.89**	15.05**	-12.31**	-12.64**
SHRIRAM RESHMA X PUSA 169	-4.15	12.24**	-10.32**	-10.28**	-10.84**	43.13**	-9.19**	-14.04**
SHRIRAM RESHMA X PB-1	-7.24**	3.86	8.98**	9.02**	-8.30**	47.20**	9.99**	9.99**
SHRIRAM RESHMA X IR 24	-8.31**	10.35**	-8.29**	2.98	-10.02**	44.44**	1.41	1.03
SHRIRAM 432 X PUSA 169	2.55	20.08**	-15.86**	-12.62**	-18.35**	25.78**	-10.71**	-10.56**
SHRIRAM 432 X PB-1	-2.27	13.44**	-8.56**	-8.56**	-11.79**	5.31	-4.08	-3.92
SHRIRAM 432 X IR 24	-7.67**	11.11**	0.31	12.64**	12.98**	34.88**	13.70**	13.88**
SHRIRAM 434 X PUSA 169	1.4	18.74**	-3.73	15.02**	5.63*	66.99**	3.1	4.82
SHRIRAM 434 X PB-1	-16.12**	-2.92	-0.81	18.52**	-7.76**	45.82**	12.07**	13.94**
SHRIRAM 434 X IR 24	76.55**	112.46**	-9.80**	7.77**	-16.40**	32.16**	-4.96	-3.38
SHRIRAM 453 X PUSA 169	-13.99**	0.71	-15.03**	-11.75**	-22.47**	19.43**	-16.95**	-9.64**
SHRIRAM 453 X PB-1	-19.29**	-3.26	-12.60**	-11.39**	-13.77**	-1.4	-11.72**	-3.95
SHRIRAM 453 X IR 24	-14.17**	3.29	-21.03**	-11.33**	-15.06**	-0.42	-10.04**	-10.38**
VIDYA 295 X PUSA 169	-14	0.7	-15.21**	-7.22**	-12.16**	45.41**	-12.90**	-10.19**
VIDYA 295 X PB-1	3.26*	15.41**	5.26**	15.18**	-8.57**	51.36**	12.28**	15.77**
VIDYA 295 X IR 24	-6.45**	12.57**	-3.25	8.64**	-11.17**	47.05**	2.24	5.42
RHR 27 X PUSA 169	-12.69**	2.24	-10.86**	-7.42**	-15.73**	29.81**	-9.02**	-4.22
RHR 27 X PB-1	-10.33*	1.01	-10.21**	-10.21**	3.87	3.87	-6.41*	-1.46
RHR 27 X IR 24	6.48**	28.14**	-4.93*	6.75**	11.60**	30.84**	8.99**	14.75**
VEDA X PUSA 169	0.97	18.24**	-7.75**	13.39**	3.11	58.84**	4.23	-0.28
VEDA X PB-1	2	14.74**	-7.51**	13.69**	-11.31**	31.71**	8.40**	3.71
VEDA X IR 24	-10.03**	8.27**	-9.11**	11.72**	-15.00**	26.23**	-3.04	-7.23*
HALCHAL X PUSA 169	-14.31**	0.35	0.46	5.46*	0.52	54.84**	0.18	3.98
HALCHAL X PB-1	-18.16**	-4.84	-6.73**	-6.73**	-20.50**	12.02**	-8.70**	-5.24
HALCHAL X IR 24	-18.40**	-1.81	-0.35	11.89	-1.07	39.39**	5.83*	9.85**
SUPER MOTI X PUSA 169	-15.33**	-0.85	-27.92**	4.52	-24.19**	16.77**	-17.83**	-12.87**
SUPER MOTI X PB-1	4.62	15.96**	-26.50**	6.57**	-15.66**	-3.52	-12.56**	-7.28*
SUPER MOTI X IR 24	5.1	11.42**	-20.35**	5.80*	-14.56**	-4.86	-9.87**	-11.56*
No. of crosses with (+) value	3	19	6	4	23	17	10	6
No. of crosses with (-) value	26	4	22	28	19	19	15	21
Range of heterosis	-27.22 to 72.89	-18.03 to 111.32	-18.66 to 10.16	-22.49 to 10.16	-11.09 to 18.61	-15.75 to 14.15	-14.17 to 14.62	-17.18 to 11.00

Table-1 Contd.......

Table-1 Contd......

Crosses	Days to 50% flowering		Days to Maturity		Plant height		EBT	
	BP	SV	BP	SV	BP	SV	BP	SV
SARJU 52 X PUSA 169	-11.96**	-8.97**	-11.96	-8.97*	-16.66**	-9.35*	-4.4	-3.94
SARJU 52 X PB-1	8.92**	8.92**	8.92**	8.92**	1.73	10.65*	-3.23	-2.77
SARJU 52 X IR 24	8.33**	2.37	8.33	2.37	-1.69	10.67**	5.18*	5.69*
NAGINA X PUSA 169	-12.14**	-9.16**	-12.14	-9.16**	-19.67**	-18.03**	2.45	-2.09
NAGINA X PB-1	-6.21*	-6.21*	-6.21	-6.21**	-13.54**	-13.54**	1.18	1.18
NAGINA X IR 24	0.79	-2.39	0.79**	-2.39*	-12.70**	-1.73	-3.3	-7.90**
JHONA X PUSA 169	4.59	8.99**	4.59**	8.99**	-2.56	0.58	-4.32	-8.56**
JHONA X PB-1	1.9	6.19*	1.90**	6.19**	-3.53	-0.42	-15.27**	-15.27**
JHONA X IR 24	-8.35**	-4.5	-8.35	-4.5	-8.95*	2.5	-2.32	-6.98**
MAGIC X PUSA 169	7.90**	11.77**	7.90**	11.77**	-11.21**	25.14**	-15.85**	-13.95**
MAGIC X PB-1	7.11**	10.96**	7.11**	10.96**	-10.25**	26.49**	-8.99**	-8.99**
MAGIC X IR 24	-6.16**	-2.79	-6.16**	-2.79**	-15.46**	19.15**	-15.02**	-13.10**
KUBER X PUSA 169	7.43**	12.26**	7.43**	12.26**	-6.42	14.38**	-13.87**	-12.02**
KUBER X PB-1	-6.07**	-1.84	-6.07**	-1.84**	-18.18**	0	10.16**	10.16**
KUBER X IR 24	9.83**	14.77**	9.83**	14.77**	72.89**	111.32**	0.49	2.63
SUMO X PUSA 169	-9.54**	-6.47**	-9.54	-6.47**	-20.23**	-7.17	-8.73**	-12.78**
SUMO X PB-1	-8.01**	-3.91	-8.01	-3.91	-18.19**	-4.8	-5.94*	-5.94*
SUMO X IR 24	-11.35**	-7.40**	-11.35**	-7.40*	-15.40**	-1.55	2.12	-2.74
SHRIRAM RESHMA X PUSA 169	-17.94**	-15.15**	-17.94**	-15.15	-20.21**	0.09	-8.88**	-12.93**
SHRIRAM RESHMA X PB-1	2.96	2.96	2.96**	2.96**	-2.05	22.86**	-11.54**	-11.54**
SHRIRAM RESHMA X IR 24	-3.73	-6.76**	-3.73**	-6.76**	-7.97*	15.44**	-12.32**	-16.50**
SHRIRAM 432 X PUSA 169	-5.96*	-2.85	-5.96**	-2.85	-11.38**	-8.79*	3.81	-0.8
SHRIRAM 432 X PB-1	-2.58	0.63	-2.58	0.63	-6.35	-3.61	2.5	2.5
SHRIRAM 432 X IR 24	12.38**	16.09**	12.38**	16.09**	5.29	18.52**	-3.94	-8.51**
SHRIRAM 434 X PUSA 169	9.31**	12.38**	9.31**	12.38**	14.07**	16.40**	1.27	-3.23
SHRIRAM 434 X PB-1	13.43**	16.62**	13.43**	16.62**	20.95**	20.95**	-12.22**	-12.22**
SHRIRAM 434 X IR 24	-4.84	-2.17	-4.84**	-2.17*	-2.29	10.00*	7.23**	2.12
SHRIRAM 453 X PUSA 169	-9.42**	-5.48**	-9.42**	-5.48**	-27.22**	7.25	-18.66**	-22.27**
SHRIRAM 453 X PB-1	-7.96**	-3.95	-7.96**	-3.95**	-26.14**	8.84*	-17.60**	-17.60**
SHRIRAM 453 X IR 24	-15.16**	-11.47**	-15.16**	-11.47**	-26.80**	7.88	-17.61**	-21.53**
VIDYA 295 X PUSA 169	-9.15**	-6.07**	-9.15**	-6.07**	-22.38**	0.99	-15.03**	-18.80**
VIDYA 295 X PB-1	15.19**	15.19**	15.19**	15.19**	-2.73	26.56**	2.42	2.42
VIDYA 295 X IR 24	5.05*	3.59	5.05**	3.59**	-8.61**	18.92**	-3.67	-8.26**
RHR 27 X PUSA 169	-5.77**	-2.57	-5.77**	-2.57**	-13.31**	7.22	-15.03**	-18.80**
RHR 27 X PB-1	-4.2	-4.2	-4.20**	-4.20**	-15.00**	5.13	-11.33**	-11.33**
RHR 27 X IR 24	8.49**	8.04**	8.49*	8.04**	0.28	24.04**	5.45*	0.43
VEDA X PUSA 169	-3.05	0.24	-3.05*	0.24*	-3.09	5.41	-0.72	-5.12*
VEDA X PB-1	-2.49	-2.49	-2.49*	-2.49*	6.47	6.47	2.73	2.73
VEDA X IR 24	-11.31**	-14.11**	-11.31	-14.11	-6.6	5.14	-9.94**	-14.23**
HALCHAL X PUSA 169	4.11	7.65**	4.11**	7.65**	-4.99	10.01*	-15.91**	-19.64**
HALCHAL X PB-1	-8.75**	-7.24**	-8.75**	-7.24**	-15.20**	-1.82	-15.81**	-15.81**
HALCHAL X IR 24	6.43**	8.18**	6.43**	8.18**	1.57	17.61**	-18.61**	-22.49**
SUPER MOTI X PUSA 169	-19.23**	-16.49**	-19.23	-16.49*	-26.13**	-0.65	-17.56**	-21.22**
SUPER MOTI X PB-1	-14.38**	-14.38**	-14.38**	-14.38**	-24.16**	2.01	2.32**	2.32**
SUPER MOTI X IR 24	-12.35**	-10.35**	-10.85**	-10.80**	-15.60**	3.3	4.45**	3.90**
No. of crosses with (+) value	21	27	2	1	3	26	2	22
No. of crosses with (-) value	10	2	24	34	25	0	33	16
Range of heterosis	-12.32 to 22.26	-6.91 to 23.72	-22.81 to 7.46	-36.38 to 5.50	-20.29 to 76.55	-4.84 to 112.46	-27.92 to 8.98	-13.19 to 23.67

Table-1 Contd......

character during the year 2015. Similar results were also reported by earlier workers (6, 7).

The estimates of heterosis values for biological yield over better parent ranged from -19.33 (SUPER MOTI x PUSA 169) to 15.19 (VIDYA295 x PB-1) and from -21.46 (SUPER MOTI x PUSA 169) to 14.76 (VIDYA295 x PB-1) per cent during study year. The extent of heterosis over standard variety ranged from -16.49 (SUPER MOTI x PUSA 169) to 16.62 (SHRIRAM434 x PB-1) and from -16.48 (SUPER MOTI x PB-1) to 18.71 (SHRIRAM432 x IR24) per cent during the study year 2015. Out of 45 crosses studied, 13 crosses over better parent and 14 crosses over standard variety showed significant positive heterosis during the year 2015. Similar results were also reported by earlier workers (6, 7).

Seventeen crosses over better parent and standard variety showed significant positive heterosis during the year 2015 for harvest index. The extent of heterosis values over better parent ranged from -17.94 (SHRIRAM RESHMA x PUSA 169) to 15.19 (VIDYA295 x PB-1) and over standard variety it ranged from -16.49 (SUPER MOTI x PUSA 169) to 16.62 (SHRIRAM 434 x PB-1) per cent. Similar results were also reported by earlier workers (6, 7).

Only three crosses i.e., KUBER x IR24, SHRIRAM434 x PUSA 169 and SHRIRAM 434 x PB-1 over better parent and 19 crosses over standard variety exhibited significant positive heterosis however, maximum of heterosis over better parent and standard variety was obtained from same crosses KUBER x IR24 with their values 72.89% and 11.32%, respectively for L:B ratio during the year 2015. Similar results were also reported by earlier workers (6, 7). These results were in confirmation with the findings of (10).

Only 6 crosses over better parent and 4 crosses over standard variety showed significant positive heterosis for yield in 2015. However, the maximum heterosis values over better parent and standard variety ranged from -18.66 (SHRIRAM 453 x PUSA 169) to 10.16 (KUBER x PB-1) per cent and from -22.49 (HALCHAL x IR24) to 10.16 (KUBER x PB-1), respectively. Similar results were also reported by earlier workers (6, 7). These results were in confirmation with the findings of (10, 11).

Results are in agreement on all the tested traits with the findings of (12, 13). While, maximum desirable heterobeltiosis and standard heterosis for harvest index was observed by (14). Significant and desirable heterosis was observed in nine crosses for tiller number, 10 for plant height, 11 for days to 50% flowering, six for panicle length, 10 for spikelets per panicle and three for spikelet fertility (%). In an ideal situation, hybrids with high tiller number, semi dwarf plant type, short days to 50% flowering, high panicle length, high spikelets per panicle, high panicle fertility and grain yield are preferable. As this situation hardly exists, compromises will have to be made among morphological traits while selecting superior genotypes (4).

It is in confirmation with experimental findings of (13, 15). Many of the crosses in present study showed low expression of heterosis for yield and its component characters which are attributed to disharmony between the gene combinations of the parents involved (16). In general, it was also observed that hybrid showing high heterosis for grain yield per plant, also manifested heterotic effects for productive tillers per plant, panicle length, number grains per panicle and 1000-grain weight. This study thus substantiates the findings of (16, 17, 18, 19, 20).

CONCLUSION

Frequency of heterotic crosses and magnitude of heterosis for yield and its components were found to be higher in crosses between the parents with intermediate genetic distance than the extreme ones. The reason for this could have been linkage of alleles for biomass and yield. It is concluded from the present experiments results, that there is the possibility to breed more sodic tolerance with agronomically adapted high yielding rice varieties than the existing tolerant varieties either through heterosis breeding or through recombinant breeding with selection in later generation can help to develop agronomically adaptable high yielding sodic tolerant rice varieties.

REFERENCES

1. Akbar M., Khush G.S., Ris H. and Lambers D. (1986). Genetics of salt tolerance in rice. *In: Proceedings of the international rice genetics symposium, IRRI*, pp 399-409.
2. Fonseca S. and Patterson F.L. (1968). Hybrid vigour in a seven parent diallel crosses in common wheat (*T. aestivum* L.). *Crop Sci. 8:* 85-95.
3. Alam M.F., Khan M.R., Nuruzzaman M., Parvez S., Swaraz A.M., Alam I. and Ahsan N. (2004). Genetic basis of Heterosis and Inbreeding Depression in Rice (*Oryza sativa* L.). *J. Zhejiang Univ. Sci., 5(4):* 406-411.
4. Bagheri N. (2010). Heterosis and combining ability analysis for yield and related-yield traits in hybrid rice. *International Journal of Biology, 2(2):* 222-231.
5. Gnansekaran M., Vivekanandan P. and Muthuramu S. (2006). Combining ability and heterosis for yield and grain quality in two line rice (*Oryza sativa* L.) hybrids. *Indian. J. Genet., 66(1):* 6-9.
6. Panwar L.L. (2005). Genetic variability, heritability and genetic advance for panicle characters in transplanted rice. *Res. on Crops, 6(3):* 505-508.
7. Rita Binse and Motiramani N.K. (2005). Study on gene action and combining ability in rice. *Oryza, 42(2):* 153-155.

8. Rosamma C.A. and Vijayakumar N.K. (2005). Heterosis and combining ability in rice (*Oryza sativa* L.). *Indian J. Genet., 65 (2):* 119-120.

9. Rao A.M., Ramesh S., Kulkarni R.S., Savithramma D.L. and Madhusudhan K. (1996). Heterosis and combining ability in rice. *Crop Imp., 23:* 53-56.

10. Sarker U., Biswas P.S., Prasad B. and Khaleque Mian M.A. (2002). Heterosis and genetic analysis in rice hybrid. *Pakistan Journal of Biological Sciences*, *5 (1):* 1-5.

11. Hossain K., AkterA., Begum H., Ansari A. and Rahman M.M. (2009). Line x tester analysis for yield and its related traits in rice (*Oryza sativa* L.). *Bangladesh J. Pl. Breed. Genet. 22(2).*

12. Parihar A. and Pathak A.R. (2008). Heterosis for quantitative traits in rice. *Oryza. 45(3):* 181-187.

13. Roy S.K., Senapati B.K., Sinhamahapatra S.P. and Sarkar K.K. (2009). Heterosis for yield and quality traits in rice. *Oryza., 46(2):* 8793.

14. Kumar S., Singh H.B., Sharma J.K. and Sood S. (2010). Heterosis for morpho physiologicsl and qualitative traits in rice. *Oryza*, *47 (1):* 17-21.

15. Veni B.K., Rani N.S. and Prasad A.S.R. (2005). Heterosis for yield components and key quality traits in basmati rice. *Oryza, 42(2):* 97102.

16. Paramasivan K.S. and Rangaswamy S.S.R. (1988). Heterosis in hybrids of rice varieties. *Oryza. 25:* 396-401.

17. Pandya R. and Tripathi R.S. (2006). Heterosis breeding in hybrid rice. *Oryza. 43(2):* 87-93.

18. Chandara N. (2012). Genetic analysis using line x tester analysis in rice (*Oryza sativa* L.). *M.Sc. (Agri.) thesis (unpublished) submitted to Navsari Agricultural University,* Navsari, Gujarat.

19. Singh C.M. and Babu G.S. (2012). Magnitude of heterosis and combining ability in relation to yield and some morphological traits for improvement of upland rice (*Oryza sativa* L.). *Madras Agric. J. 99(7-9):* 447-453.

20. Pratap N., Shekhar R., Singh P.K. and Soni S.K. (2013). Combining ability, gene action and heterosis using cms lines in hybrid rice (*Oryza sativa* L.). *The Bioscan. 8(4):* 1521-1528.

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