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STUDIES ON HETEROSIS FOR VARIOUS PHYSIOLOGICAL CHARACTERS IN RICE (*ORYZA SATIVA* L.) UNDER COASTAL SALINE SOIL CONDITIONS

M. SUDHA RANI[1]* AND G. USHARANI[2]
Agicultural Research Station,Machilipatnam - 521 001, Andra Pradesh,INDIA
[1]Seed Research and Technology Centre, Rajendranagar, Hyderabad - 500 030, INDIA
[2]Regional Agricultural Research Station, Palem, Mahabubnagar - 509 215, INDIA
e-mail: sudharaniagrico@gmail.com

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***Corresponding author**

ABSTRACT

The heterotic trends among 28 F_1 hybrids in rice under saline and normal soil conditions revealed severe reduction in number of heterotic hybrids and the range of heterosis of all types under stressed environment compared to favorable soil environment. The hybrid Swarna x CSRC(S)7-1-4 manifested significant heterotic expression over mid and better-parents for root/shoot ratio, harvest index and desirable negative heterosis for Na^+/K^+ ratio. Similarly, the hybrid RPBio-226 x CSR-30 was also found to be heterotic over mid and better-parents with low inbreeding depression for all the traits studied. These promising rice hybrids identified from the present study for physiological characters could be utilized further for commercial exploitation under saline soil conditions.

INTRODUCTION

Rice (*Oryza sativa* L.) is a medium salt-resistant crop and its varieties exhibit variability in sensitivity to salinity conditions (IRRI, 1994). Salt stress like many other abiotic stresses can considerably suppress growth and development of a number of plants (Naz *et al.,* 2010). Salinity impairs seed germination, reduces tiller production, retards plant development and reduces crop yield (Greenway and Munns, 1980). Most rice cultivars are severely injured in sub-merged soil cultured on electrical conductivity (EC) of 8 to 10 dSm^{-1} at 25ºC, but sensitive cultivars are damaged even at 2 dSm^{-1} hence, the present study was undertaken (Mass and Hoffman, 1977). Extremely high salt concentration kills the plant but moderate salt stress exhibits the growth differences among crop varieties. Improving salt tolerance of crops is necessary for sustainable food production in different saline regions (Pitman and Lauchli, 2002).

The exploitation of hybrid vigour is an appropriate alternative for making further breakthrough in rice yield under these stressed conditions. However, reports on heterosis in rice under salinity are limited. Identification of recombinants with higher vigour for physiological traits *viz*., standard evaluation score (SES) for salt injury, root/shoot ratio, harvest index and Na/K ratio that are related to salinity tolerance is very crucial along with agronomic traits for increasing the grain yield under stressed soil conditions. The ideal high yielding saline tolerant variety should withstand high amount of Na^+, per day uptake of Na^+ is minimum, high uptake of K^+ per day, good initial vigour and agronomically superior with high yield potential. The present study was undertaken to draw valid conclusions regarding the extent of heterosis for various physiological characters under saline as well as normal soil conditions.

MATERIALS AND METHODS

Study area

During *kharif* 2010, staggered sowings of eight selected parents (RP Bio-226, Swarna, CSR-27, CSR-30, CST-7-1, CSRC(S)7-1-4, SR26B and CSRC(S)5-2-2-5) were taken up at Rice Section, ARI, Rajendranagar, Hyderabad and crosses were effected in half diallel manner. The half diallel set (28 hybrids) along with eight parents were sown during *kharif*, 2011 in randomized block design (RBD) design under both normal and coastal saline soils of Agricultural Research Station, Machilipatnam. The saline soils were of sandy loam in texture with an average electrical conductivity of 6.3 dSm^{-1} and pH of 7.9. The normal soil had an EC of 0.23 dSm^{-1} and pH of 7.3. The source of irrigation for both the situations was canal water. From each replication, observations were recorded on 15 randomly selected plants from each of parents and F_1s and the data were recorded on four physiological traits *viz*., SES for visual salt injury, root/shoot ratio, harvest index and Na^+/K^+ ratio which are related to salinity tolerance. Relative heterosis was expressed as % deviation of mean of F_1 from its mid parental value between two corresponding parents as per the formula given by Fonseca and Patterson (1968). Heterobeltiosis was estimated as difference between the mean of the F$_1$ and that of the parent with greater expression as per the formula of Liang *et al*. (1971). Standard heterosis was calculated as the % deviation of mean of F$_1$ from standard parent (SR 26- B) according to Virmani *et al.* (1982). Parent with higher value for the character was reckoned as better parent for the respective character except SES for visual salt injury, Na$^+$/K$^+$ ratio for which, parent having low value was considered as better parent.

Statistical Analysis

The significance of heterosis was tested by using 't' test as suggested by Snedecor and Cochran (1967) and Paschal and Wilcox (1975). Inbreeding depression is usually associated with reduction in vigour, fertility and productivity and calculated for hybrids under stressed environment according to Miller and Marani (1963).

RESULTS AND DISCUSSION

The magnitude of relative heterosis, heterobeltiosis and standard heterosis was estimated for four physiological attributes related to salt tolerance. SES of visual salt injury is an important parameter for selection of saline tolerant genotypes for which the heterosis in negative direction is desirable. The hybrids Swarna x CSR30 followed by CSR30 x CST-7-1 and RPBio-226 x Swarna exhibited higher magnitude (>25%) of all the three types of heterotic effects in the desired negative direction under both the soil conditions with high inbreeding depression of -79, -33.3 and -59 %, respectively, indicating the lesser possibility of exploiting these cross combinations in the segregating generations (Table 1). Similar results were reported by Senguttuvel (2008) under saline conditions.

Eight hybrids were significantly positive in exhibiting heterobeltiosis for root/shoot ratio ranging from 14.93 % (RPBio-226 x CSRC(S)5-2-2-5) to 92.17 % (CSRC(S)7-1-4 x CSRC(S)5-2-2-5). The number of hybrids that exhibited significant standard heterosis were 15 with lowest effect of 19.17 observed in CSRC(S)7-1-4 x SR26-B and SR26-B x CST-7-1, while the highest heterotic effect seen in CSRC(S)7-1-4 x CST-7-1 (96.67 %) under normal conditions (Table 2). At the same time under salt stressed situation, heterobeltiosis was exhibited by four cross combinations with a range of 10.29 % (RPBio-226 x CST-7-1) to 23.85 % (RPBio-226 x Swarna). The hybrid Swarna x CSRC(S)7-1-4 recorded significant mid-parent heterosis (17.95 %) and standard heterosis over SR26-B (15.72 %) followed by high inbreeding depression of 7.61 %, which indicated the further reduction of root/shoot ratio in the later generations under these conditions. However, the hybrid CST-7-1 x CSRC(S)5-2-2-5 also recorded significant heterosis over mid-parent and better-parents under saline soils and had low inbreeding depression (6.47 %) which would allow to isolate individual plant with more root dry weight thereby imparting salinity tolerance.

Under ambient soil conditions, 11 hybrids were superior to better-parent and showed significant heterobeltiosis to a tune of 11.06 % (RPBio-226 x CSR-27) to 19.91 % (CSR-27 x SR26-B) for harvest index (Table 3). Eight cross combinations exhibited significant positive standard heterosis ranging from 11.25 % (CSRC(S)7-1-4 x CST-7-1) to 16.30 % (CSR-27 x SR26-B). Under saline soils, heterosis for harvest index was restricted only to mid-parent denoting the severe impact of salinity stress

Table 1 :Estimates of heterosis (H1), heterobeltiosis (H2) and standard heterosis (H3) in rice for SES for visual salt injury under saline and normal soils and inbreeding depression (I.D) under saline soils

Hybrids	H1		H2		H3		I.D.
	S	N	S	N	S	N	S
RPBio-226 × Swarna	-62.56**	-27.13**	-64.92**	-37.74**	-27.23**	44.83*	-59.08
RPBio-226 × CSR-27	-31.21**	-21.55*	-43.86**	-35.71**	16.45	49.53*	-32.8
RPBio-226 × CSR-30	-19.41**	-47.22**	-30.12**	-53.23**	44.96**	8.78	-22.03
RPBio-226 × CSRC(S)7-1-4	-26.61**	-11.74	-45.70**	-29.11**	12.63	64.89**	-38.52
RPBio-226 × SR26-B	-9.53	-35.16**	-32.96**	-53.64**	39.08**	7.84	7.32
RPBio-226 × CST-7-1	-38.51**	-50.26**	-50.42**	-55.12**	2.84	4.39	-11.33
RPBio-226 × CSRC(S)5-2-2-5	-36.43**	-33.15**	-51.79**	-51.35**	0	13.17	-26.93
Swarna × CSR-27	-35.49**	18.2	-44.41**	12.36	0.78	85.27**	-2.24
Swarna × CSR-30	-56.78**	-32.30**	-60.24**	-35.08**	-27.91**	16.61	-79.35**
Swarna × CSRC(S)7-1-4	-33.73**	-12.7	-48.68**	-19.01	-6.95	33.54	3.16
Swarna × SR26-B	-22.01**	6.51	-39.49**	-14.45	9.7	41.07*	-1.96
Swarna × CST-7-1	-39.39**	27.52**	-48.46**	19.93	-6.56	124.45**	-22.33
Swarna × CSRC(S)5-2-2-5	-28.69**	17.59	-43.27**	-3.42	2.84	59.25**	-7.33
CSR-27 × CSR-30	8.5	-28.37**	0.96	-34.55**	53.77**	17.55	-11.27
CSR-27 × CSRC(S)7-1-4	31.97**	7.14	16.06*	4.43	52.20**	55.17**	-11.13
CSR-27 × SR26-B	-11.95	86.63**	-22.40**	56.12**	1.76	131.97**	-14.24*
CSR-27 × CST-7-1	-5.92	-8.5	-7.39	-17.92	21.45*	53.61**	-1.77
CSR-27 × CSRC(S)5-2-2-5	-19.85**	10.59	-27.18**	-5.27	-4.51	40.75*	-14.97*
CSR-30 × CSRC(S)7-1-4	37.22**	-11.83	13.44*	-21.29	72.77**	41.38*	-0.79
CSR-30 × SR26-B	27.33**	-18.16	5.47	-36.30**	60.63**	14.42	-6.95
CSR-30 × CST-7-1	-46.77**	-25.81**	-51.19**	-27.30**	-25.66**	36.05	-33.33*
CSR-30 × CSRC(S)5-2-2-5	-4.11	22.5	-18.33**	-2.62	24.39**	74.92**	-2.2
CSRC(S)7-1-4 × SR26-B	-3.68	-3.51	-3.92	-17.56	-3.92	16.3	-8.26
CSRC(S)7-1-4 × CST-7-1	36.10**	10.22	21.36**	-3.35	54.16**	80.88**	-8.83
CSRC(S)7-1-4 × CSRC(S)5-2-2-5	6.82	16.5	3.02	2	10.38	43.89*	-6.83
SR26-B × CST-7-1	-25.88**	-17.47	-33.77**	-36.68**	-15.87	18.5	-2.79
SR26-B × CSRC(S)5-2-2-5	-2.6	66.82**	-5.85	62.13**	0.88	71.79**	-11.65
CST-7-1 × CSRC(S)5-2-2-5	-10.5	9.3	-17.50*	-14.41	4.8	60.19**	-17.94
SE±	0.26	0.17	0.3	0.2	0.03	0.2	0.02

* Significant at p d•0.05; ** Significant at p ≤0.01; S: Saline; N: Normal

Table 2: Estimates of heterosis (H1), heterobeltiosis (H2) and standard heterosis (H3) in rice for root / shoot ratio under saline and normal soils and inbreeding depression (I.D) under saline soils

Hybrids	H1		H2		H3		I.D.
	S	N	S	N	S	N	S
RPBio-226 × Swarna	26.77**	9.75	23.85**	6.29	1.26	26.67**	16.15
RPBio-226 × CSR-27	0.35	13.68*	-10.69*	7.28	-10.69*	35.00**	7.75
RPBio-226 × CSR-30	-11.34**	-20.95**	-22.75**	-27.78**	-18.87**	-2.5	15.50*
RPBio-226 × CSRC(S)7-1-4	-5.23	10.84	-20.33**	2.99	-8.81*	15	4.14
RPBio-226 × SR26-B	-33.57**	-31.50**	-40.88**	-35.07**	-40.88**	-27.50**	2.13
RPBio-226 × CST-7-1	15.38**	8.61	10.29*	8.21	-5.66	20.83**	10.67
RPBio-226 × CSRC(S)5-2-2-5	23.47**	25.71**	11.76**	14.93*	7.55	28.33**	7.02
Swarna × CSR-27	-6.57	21.09**	-15.09**	17.88**	-15.09**	48.33**	-8.89
Swarna × CSR-30	13.80**	27.87**	1.2	20.37**	6.29	62.50**	8.28
Swarna × CSRC(S)7-1-4	17.95**	26.36**	1.1	13.99*	15.72**	35.83**	7.61*
Swarna × SR26-B	-7.96	-24.71**	-16.35**	-30.77**	-16.35**	-17.50*	6.77
Swarna × CST-7-1	-22.56**	19.57**	-24.26**	15.38*	-35.22**	37.50**	-2.91
Swarna × CSRC(S)5-2-2-5	-30.04**	5.51	-35.29**	-6.29	-37.74**	11.67	-17.17
CSR-27 × CSR-30	-35.58**	-21.41**	-37.13**	-24.07**	-33.96**	2.5	-0.95
CSR-27 × CSRC(S)7-1-4	-33.72**	-0.75	-37.91**	-12.58*	-28.93**	10	3.54
CSR-27 × SR26-B	-8.81*	-14.39*	-8.81*	-23.18**	-8.81*	-3.33	10.34
CSR-27 × CST-7-1	-32.88**	-45.07**	-37.74**	-48.34**	-37.74**	-35.00**	-7.07
CSR-27 × CSRC(S)5-2-2-5	8.33*	16.79**	6.29	1.32	6.29	27.50**	4.14
CSR-30 × CSRC(S)7-1-4	-28.37**	-5.42	-31.32**	-19.14**	-21.38**	9.17	0.8
CSR-30 × SR26-B	-35.58**	-37.59**	-37.13**	-45.68**	-33.96**	-26.67**	5.71
CSR-30 × CST-7-1	-2.97	-8.47	-11.98**	-16.67**	-7.55	12.5	7.48
CSR-30 × CSRC(S)5-2-2-5	-11.87**	12.82*	-15.57**	-4.94	-11.32**	28.33**	9.22
CSRC(S)7-1-4 × SR26-B	-2.64	21.70**	-8.79*	19.17*	4.4	19.17*	22.29**
CSRC(S)7-1-4 × CST-7-1	5.66	90.32**	-7.69*	77.44**	5.66	96.67**	13.1
CSRC(S)7-1-4 × CSRC(S)5-2-2-5	-5.67	95.58**	-13.19**	92.17**	-0.63	84.17**	7.59
SR26-B × CST-7-1	12.54**	13.04*	4.4	7.52	4.4	19.17*	9.04
SR26-B × CSRC(S)5-2-2-5	1.92	-4.76	0	-8.33	0	-8.33	1.26
CST-7-1 × CSRC(S)5-2-2-5	17.65**	63.93**	11.11*	50.38**	6.92	66.67**	6.47
SE±	0.02	0.03	0.02	0.03	0.02	0.03	0.01

* Significant at $p \leq 0.05$; ** Significant at $p \leq 0.01$; S: Saline; N: Normal

Table 3: Estimates of heterosis (H1), heterobeltiosis (H2) and standard heterosis (H3) in rice for Harvest index (%) under saline and normal soils and inbreeding depression (I.D) under saline soils

Hybrids	H1		H2		H3		I.D.
	S	N	S	N	S	N	S
RPBio-226 × Swarna	23.1	10.13*	21.48	9	0.94	9.33	5.02
RPBio-226 × CSR-27	21.99	13.40**	21.87	11.06*	-1.4	9.1	4.74
RPBio-226 × CSR-30	-14.11	7.35	-14.93	-0.47	-31.18**	-2.22	-25.93
RPBio-226 × CSRC(S)7-1-4	13.42	16.99**	5.56	15.58**	-0.86	13.54*	8.65
RPBio-226 × SR26-B	5.13	3.67	-4.91	2.75	-4.91	2.75	11.48
RPBio-226 × CST-7-1	-1.53	7.22	-7.82	6.46	-14.5	4.59	2.73
RPBio-226 × CSRC(S)5-2-2-5	21.1	7.43	15.83	7.39	2.65	5.59	7.97
Swarna × CSR-27	16.37	5.98	14.73	2.75	-4.68	3.06	14.64
Swarna × CSR-30	25.43	21.26**	22.61	11.37*	1.87	11.71*	10.94
Swarna × CSRC(S)7-1-4	26.38*	-0.23	19.09	-2.44	11.85	-2.14	9.48
Swarna × SR26-B	10.43	10.24*	1.09	10.07	1.09	10.41	5.71
Swarna × CST-7-1	3.01	6.79	-2.35	4.96	-9.43	5.28	2.93
Swarna × CSRC(S)5-2-2-5	-8.67	-12.63**	-11.52	-13.50*	-21.59	-13.24*	-14.12
CSR-27 × CSR-30	13.63	15.29**	12.64	9.02	-9.04	2.68	0.6
CSR-27 × CSRC(S)7-1-4	-2.28	13.20**	-9.13	12.21*	-14.65	7.57	-2.83
CSR-27 × SR26-B	16.6	19.78**	5.38	16.30**	5.38	16.30**	11.39
CSR-27 × CST-7-1	8.09	21.59**	1.09	19.91**	-6.24	16.14**	-2.33
CSR-27 × CSRC(S)5-2-2-5	30.51*	15.98**	24.71	13.54*	10.52	11.63*	8.04
CSR-30 × CSRC(S)7-1-4	-11.56	18.30**	-18.42	10.93	-23.38	6.35	-9.97
CSR-30 × SR26-B	-14.47	9.98	-23.3	1.15	-23.3	1.15	-7.72
CSR-30 × CST-7-1	5.71	22.39**	-1.93	14.22*	-9.04	10.64	-2.74
CSR-30 × CSRC(S)5-2-2-5	2.74	12.26*	-2.64	4.05	-13.72	2.3	-16.53
CSRC(S)7-1-4 × SR26-B	-1.05	13.59**	-4.05	11.25*	-4.05	11.25*	-2.11
CSRC(S)7-1-4 × CST-7-1	-14.66	1.63	-15.19	1.11	-20.34	-2.07	8.81
CSRC(S)7-1-4 × CSRC(S)5-2-2-5	18.79	15.13**	15.44	13.70*	8.42	11.78*	6.9
SR26-B × CST-7-1	15.24	11.39*	11.07	9.64	11.07	9.64	10.95
SR26-B × CSRC(S)5-2-2-5	16.45	15.59**	9.82	14.61**	9.82	14.61**	9.01
CST-7-1 × CSRC(S)5-2-2-5	5.89	10.39*	3.53	9.57	-3.98	7.73	-6.9
SE±	4.36	1.97	5.03	2.27	5.03	2.27	4.43

* Significant at $p \leq 0.05$; ** Significant at $p \leq 0.01$; S: Saline; N: Normal

on this trait. Out of 28 hybrids studied, only two combinations namely, CSR-27 x CSRC(S)5-2-2-5 (30.51 %) and Swarna x CSRC(S)7-1-4 (26.38 %) exhibited significant positive heterosis over mid-parent followed by low inbreeding depression of 8.04 % and 9.5 % respectively. Present findings are in line with the reports of Malar*vizhi* *et al.* (2004) and Singh *et al.*

Table 4: Estimates of heterosis (H1), heterobeltiosis (H2) and standard heterosis (H3) in rice for Na^+/K^+ ratio under saline and normal soils and inbreeding depression (I.D) under saline soils

Hybrids	H1		H2		H3		I.D.
	S	N	S	N	S	N	S
RPBio-226 × Swarna	-17.53**	-20.00*	-26.52**	-23.29*	498.13**	97.65**	0
RPBio-226 × CSR-27	28.76**	-24.79*	-8.5	-32.84**	644.86**	58.82*	-1.88
RPBio-226 × CSR-30	-20.22**	-59.50**	-40.64**	-59.70**	383.18**	-4.71	-11.8
RPBio-226 × CSRC(S)7-1-4	-13.66*	-71.66**	-48.11**	-74.13**	322.43**	-38.82	-3.98
RPBio-226 × SR26-B	-52.35**	36.36**	-73.25**	-2.99	117.76**	129.41**	-8.15
RPBio-226 × CST-7-1	10.62	-41.47**	-25.83**	-45.49**	503.74**	49.41	0
RPBio-226 × CSRC(S)5-2-2-5	-37.87**	47.92**	-60.16**	41.29**	224.30**	234.12**	-19.88
Swarna × CSR-27	45.04**	34.22**	11.60*	15.53	610.28**	197.65**	9.87
Swarna × CSR-30	28.93**	-18.66*	4.7	-22.37*	566.36**	100.00**	-7.71
Swarna × CSRC(S)7-1-4	-60.56**	-30.91**	-75.18**	-39.27**	57.94	56.47*	-31.95
Swarna × SR26-B	-21.32*	46.71**	-54.48**	1.83	189.72**	162.35**	-6.45
Swarna × CST-7-1	28.83**	14.16	-7.49	10.73	488.79**	203.53**	-8.41
Swarna × CSRC(S)5-2-2-5	19.74**	-48.26**	-18.50**	-52.51**	418.69**	22.35	1.44
CSR-27 × CSR-30	77.78**	57.42**	65.65**	41.21**	557.94**	230.59**	-16.62
CSR-27 × CSRC(S)7-1-4	214.55**	48.77**	132.70**	45.18**	698.13**	183.53**	11.01
CSR-27 × SR26-B	87.34**	171.60**	20.98	108.86**	314.95**	288.24**	-4.28
CSR-27 × CST-7-1	12.95	31.97**	2.18	10.73	250.47**	203.53**	-15.47*
CSR-27 × CSRC(S)5-2-2-5	-38.66**	-12.61	-48.77**	-18.58	75.70*	75.29**	12.77
CSR-30 × CSRC(S)7-1-4	176.54**	-21.64*	95.53**	-28.14*	676.64**	68.24**	10.59
CSR-30 × SR26-B	225.56**	96.48**	103.76**	40.20**	709.35**	228.24**	26.44*
CSR-30 × CST-7-1	65.93**	10.19	40.94**	2.15	459.81**	180.00**	4.84
CSR-30 × CSRC(S)5-2-2-5	67.81**	8.38	32.47**	4.02	426.17**	143.53**	6.93
CSRC(S)7-1-4 × SR26-B	71.73**	32.27*	38.07	0	127.10**	95.29**	-12.76
CSRC(S)7-1-4 × CST-7-1	323.26**	22.81*	237.04**	5.15	835.51**	188.24**	6.79
CSRC(S)7-1-4 × CSRC(S)5-2-2-5	25.12	15.19	7.32	9.84	146.73**	136.47**	-8.33
SR26-B × CST-7-1	-36.14*	-48.43**	-56.57**	-64.81**	20.56	-3.53	-24.81
SR26-B × CSRC(S)5-2-2-5	4.25	8.96	-25.2	-20.22	71.96	71.76**	-7.61
CST-7-1 × CSRC(S)5-2-2-5	-42.91**	-47.12**	-47.81**	-52.79**	44.86	29.41	-45.16
SE±	0.11	0.06	0.13	0.07	0.13	0.07	0.12

* Significant at $p \leq 0.05$; ** Significant at $p \leq 0.01$; S: Saline; N: Normal

Table 5 : Promising heterotic hybrids along with general and specific combining ability effects under saline soils

S. No.	Character	Hybrid	Heterosis			*Per se* performance				GCA of the parents	Value of SCA effect
			H_1	H_2	H_3	P_1	P_2	F_1	F_2		
1	SES for visual salt injury	RPBio-226 x Swarna	-62.56**	-64.92**	-27.23**	7.06	6.17	2.48	5.26	Low x high	-1.81**
		Swarna x CSR-30	-56.78**	-60.24**	-27.91**	6.17	5.18	2.45	3.07	High x low	-1.85**
		CSR-30 x CST-7-1	-46.77**	-51.19**	-25.66**	5.18	4.32	2.53	4.33	Low x high	-1.71**
2	Root/shoot ratio	RPBio-226 x Swarna	26.77**	23.85**	1.26	0.41	0.43	0.54	0.44	Low x low	0.01**
		CST-7-1 x CSRC(S)5-2-2-5	17.65**	11.11*	6.92	0.45	0.51	0.47	0.44	Low x high	0.07**
		Swarna x CSRC(s)7-1-4	17.95**	1.1	15.72**	0.43	0.61	0.61	0.41	Low x high	0.11**
3	Harvest index(%)	Swarna x CSR(S)7-1-4	26.38**	19.09	11.85	35.53	40.17	47.83	40.77	Low x low	7.32*
		CSR-27 x CSRC(S)5-2-2-5	30.51*	24.71	10.52	34.53	39.7	47.27	36.03	Low x low	5.91*
		RPBio-226 x Swarna	23.1	21.48	0.94	34.6	35.53	43.17	40.17	Low x low	4.03
4	Na^+/K^+ ratio	Swarna x CSRC(S)7-1-4	-60.56**	-75.18**	57.94	2.27	0.59	0.56	1.1	Low x low	-1.25**
		SR26-B x CST-7-1	-36.14*	-56.57*	20.56	0.36	0.99	0.43	0.66	High x high	-0.54**

H1: Heterosis, H2: Heterobeltiosis, H3: Standard Heterosis, P1: Female parent, P2: Male parent, F_1: First filial generation and F_2: Second filial generation * Significant at $p \leq 0.05$; ** Significant at $p \leq 0.01$

(2006).

Under the stressed environment, the number of hybrids with significant heterosis over better-parent for Na^+/K^+ increased to 12 and they ranged between -18.50 % (Swarna x CSRC(S)5-2-2-5) and -73.25 % (RPBio-226 x CSRC(S)7-1-4) and also expressed low inbreeding depression indicating the superiority of these hybrids in maintaining low Na^+ concentration in the plant systems (Table 4). By virtue of superior performance of SR26-B through lesser intake of Na^+ ions into the plant system, heterotic effects were not realized. Heterosis and heterobeltiosis in both directions were also reported by Sajjad (1986) and Thirumeni and Subramanian (2000) under saline soil conditions. In contrast to the absence of standard heterosis in the present study, mixed trend of all sorts of heterosis was noticed by Senguttuvel (2008).

The magnitude of heterosis over mid-parent, better-parent and standard checks varied from cross to cross and environment to environment for physiological components. All the traits distinctly differed for heterosis and ranged in both the directions, which indicates that, in different cross combinations different pathways are present to realize the heterotic effects. Considerable higher magnitude of heterosis under normal soils in certain hybrids and lower degree of heterotic effects under stressed environment revealed that, nature of gene action manifested differently with the genetic makeup of parents as well as with environmental conditions. The differential sensitivity of different plant attributes to salt stress in rice has been well elucidated (Sajjad, 1983; 1984a and 1984b) and perhaps the same phenomenon may have been involved in the present study. However, significant standard heterosis in the desired direction was not observed for harvest index and Na^+/K^+ ratio. In these traits heterosis under saline condition was restricted only to better-parent.

The hybrids SR26-B x CST7-1 for root shoot ratio; RPBio-226 x SR26-B for SES for visual salt injury symptoms exhibited significant heterotic expression, but showed reduced performance in F_2 generation. This must be due to intra and inter allelic non-additive gene

action (dominance and over dominance) associated with heterozygosity. Hence, heterosis may be exploited in these combinations (Table 5).

The hybrids *viz*., Swarna x CSR-30 for SES for visual salt injury symptoms ; RPBio-226 x CSRC(S)5-2-2-5 for harvest index; CSR-30 x SR26-B for Na^+/K^+ ratio; Heterosis in these crosses was probably due to complementary genes largely with additive effects. Hence, more emphasis may be given to these cross combinations to identify desirable saline tolerant plants.

The hybrids Swarna x CSRC(S)7-1-4, RPBio-226 x CSR-30 and CST-7-1 x CSRC(S)5-2-2-5 were found to be promising with significant heterosis, *per se,* high general combining ability for one of the parents and sca effects for majority of the traits, besides having low inbreeding depression under saline soil conditions. This indicates the scope of developing superior early maturing varieties with salt tolerance related physiological attributes under such stressed conditions.

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