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ASSESSMENT OF HETEROTIC EFFECTS IN RICE (*ORYZA SATIVA* L.) COASTAL SALINE ENVIRONMENT

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Abstract

The recent approach for rice production includes the improvement of yield is necessary to cater for consumer demand. Therefore, a field experiment was conducted using Line × Tester mating design for yield and yield attributing traits under coastal saline environmental condition by using 12 parents (8 Lines and 4 Testers) and 32 hybrids. A total 32 hybrids with their 12 parents with standard check IR 20, were evolved for heterobeltiosis and standard heterosis. The hybrids *viz.,* KULLAKAR × IR 36, ASHWANI × ADT 37, ADT 39 × ADT 45 and ASHWANI × ADT 45 were found to be best for exploitation of heterosis based on standard heterosis pertaining to grain yield per plant while the cross combination, KULLAKAR × IR 36 and ASHWANI × ADT 37 showed highly significant negative standard heterosis for earliness and short stature nature apart from grain yield.

Key words : Rice genotypes, heterosis, L×T, saline environment.

Introduction

Rice (*Oryza sativa* L. 2n=24) is the most important cereal grain and food stuff, which forms an important part of the diet of more than three billion people around the world and popularly called as "Global grain". The area under rice cultivation in India was 43.5 million hectares with a production of 103 million tonnes during 2015-2016 (USDA Grain Report, 2016). In Tamil Nadu, area under rice cultivation was 1795 hectares with a production of 5727 tonnes in 3191 kg/hectares during 2014-2015 (Indiastat Report, 2015). Rice cultivation has been predominant in India across ages. Salinity is the second most important abiotic stress after drought that hampers rice productivity. The extent and distribution of saline affected soil in India was 1710673 hectares and 1246136 hecrares affected with coastal saline soil. In Tamil Nadu about 13231 hectares affected with coastal saline soil (CSSRI Report, 2016). Breeding for salt tolerance offers more promising, energy efficient, economical, and socially acceptable approach to overcome problems related to the salt-stress (Ray and Islam, 2008). For the extent success in a breeding programme, the method of parent selection for hybridization is considered as a basic factor. Here, line × tester technique which was developed by Kempthorne (1957) was used. To develop new varieties with a high level of salinity tolerance, it requires an understanding of the genetic control underlying salt tolerance mechanisms. Rice is considered to be sensitive to salinity, particularly during early vegetative and later at reproductive stages. Salt stress like many other abiotic stresses can considerably suppress the growth and development of a number of a plant.

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Materials and Methods

Twelve selected genotypes of which eight genotypes (ADT 43, NLR 34449, AKSHYA, PONNI, ADT-39, KULLAKAR, ASHWANI and GIRI) were used as lines and four varieties (ADT 37, ADT 45, IR 36 and IR 20), as testers. These parents are crossed to produce thirty two hybrids using line x tester mating design (Kempthorne, 1957). A total thirty two hybrids with twelve parents along with check variety, IR 20 were evaluated under coastal saline with EC of soil ranged from 3.5 to 4.0 dSm^{-1}. The study was conducted at Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University during Samba (July - October 2016) season. Twenty three days old seedlings were transplanted and two seedlings per hill was maintained.

The row length of 3 m was maintained for each genotype. The experiment was laid out in a randomized block design with three replications. Recommended cultural practices and need based plant protection measures were also adopted to raise the crop. Observations were recorded on ten competitive plants both in parents and hybrids in each replication for the following eleven traits *viz.,* days to 50 per cent flowering, plant height at maturity, number of tillers per plant, number of productive tillers, panicle length, number of grains per panicle, kernel length, kernel breadth, kernel L/B ratio, hundred grain weight and grain yield per plant.

Heterosis

The mean of parents and F_1 hybrids were utilized for the estimation of heterosis. The heterobeltiosis (d_{ii}) and standard heterosis (d_{iii}) were estimated as follows:

$$\text{Heterobeltiosis } (d_{ii}) = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} X100$$

$$\text{Standard heterosis } (d_{iii}) = \frac{\overline{F_1} - \overline{SV}}{\overline{SV}} X100$$

Where,

F_1 = mean of the F_1 hybrid

BP = mean of the better parent

SV = mean of the standard variety

In the present study, IR 20 was considered as the standard parent.

Test of significance of heterosis

The significance of heterosis was tested using the formula as suggested by Wynne *et al.* (1970).

i. 't' over Heterobeltiosis (d_{ii}) $= \dfrac{F_1 - BP}{\left(2\sigma^2{}_e / r\right)^{1/2}}$

ii. 't'over standard heterosis(d_{iii}) $= \dfrac{F_1 - SV}{\left(2\sigma^2{}_e / r\right)^{1/2}}$

Where,

'σ^2_e' is the error variance obtained from the analysis of variance.

'r' is the number of replications. The calculated 't' value was compared with the table of 't' at the error degrees of freedom.

Results and Discussion

The values of heterosis for hybrids were estimated based on better parent (d_{ii}) and standard parent performance (d_{iii}) (table 1). Negative heterosis for days to fifty per cent flowering is desirable for breeding early maturing hybrids and varieties. In this trait most of the hybrids exhibited negative significant values in heterobeltiosis. The maximum significant and negative value was recorded in cross KULLAKAR × IR 20 (-30.71 per cent) followed by ASHWANI × IR 20 (-24.74 per cent). Twenty one hybrids showed negatively significant values ranged from -30.71 to -4.79 per cent for for days to fifty per cent flowering for standard heterosis The crosses KULLAKAR × IR 20, KULLAKAR × ADT 45, ADT-39 × ADT 45 recorded significantly negative values in higher order with the values of -30.71, -27.35 and -25.33 per cent respectively. The significant heterosis was also recorded by Padmavathi *et al*. (2013).

Negative heterosis is a desiarable plant height for breeding short statured hybrids and varieties. For heterobeltiosis, values ranged from -35.38 to -2.54 per cent. The maximum significant and negative value was recorded by KULLAKAR × ADT 37 (-35.38 per cent). Twenty nine crosses were recorded negatively significant standard heterosis which ranged from -36.66 to -1.75 per cent. The highly significant and negative value was recorded by the cross KULLAKAR × ADT 45 (-36.66 per cent) for plant height. The present findings are in accordance with the earlier of Tiwari *et al*. (2011) and Ammer Gholizadeh Ghara *et al*. (2014).

For number of tillers per plant in heterobeltiosis was positive and significant for eleven hybrids and ranged from 14.72 to 40.90 per cent. The highest significant and positive heterobeltiosis was observed in cross GIRI × IR 20 (40.90 per cent). Twenty three hybrids recorded significantly positive standard heterosis which ranged from 13.60 to 91.25 per cent. The maximum significantly positive standard heterosis was noticed in KULLAKAR × IR 36 (91.25 per cent).

Number of productive tillers is one of the important yield contributing component trait. Twenty hybrids were recorded with positive and significant values in heterobeltiosis, the hybrid ADT-39 × ADT 45 (30.01 per cent) showed the maximum and significantly positive value. Twenty hybrids recorded significantly positive standard heterosis ranged from 18.73 to 90.11 per cent. The maximum significantly positive standard heterosis was observed in KULLAKAR × IR 36 (90.11 per cent). For this trait these result are similar with the findings of Umakanta sarker *et al* (2002).

Among the hybrids estimated for heterobeltiosis, ADT 43 × IR 20 was recorded the maximum positive significant value (78.36 per cent) panicle length, twenty four hybrids were recorded positively significant standard heterosis. Among them, ADT-39 × ADT 45 (93.93 per cent) recorded the maximum significant positive value for panicle length. The similar result findings of Ammer Gholizadeh Ghara *et al*. (2014).

Table 1 : Extend of heterosis over better parent and standard variety in thirty two rice hybrids for eleven characters.

Cross	Days to 50 per cent flowering (days)		Plant height at maturity (cm)		Number of tillers per plant		Number of productive tillers per plant		Panicle length (cm)		Number of grains per panicle		Kernel length		Kernel breadth		Kernel L/B ratio		Hundred grain weight (g)		Grain yield per plant (g)	
	dii	diii	dii	diii	dii	diii	dii	diii	dii	diii	dii	diii	dii	diii	dii	diii	dii	diii	dii	diii	dii	diii
ADT 43 x ADT 37	-0.69	-17.72	-8.65	-2.60	-5.40	7.93	-18.73	0.90	-1.16	21.01	-7.27	58.55	8.65	15.78	1.27	24.36	-19.57	-7.58	-21.34	-3.49	-15.25	27.29
ADT 43 x ADT 45	-7.16	-23.08	-14.35	-8.68	-38.93	-27.85	-30.43	-18.92	-7.15	6.97	-19.07	38.37	-10.28	7.17	35.99	25.78	-35.62	-15.16	-16.67	0.35	-7.81	30.65
ADT 43 x IR 36	-6.35	-17.28	-11.16	-5.27	-22.52	4.90	-24.30	6.03	23.12	61.49	-15.13	45.11	-5.91	15.94	9.19	0.99	-21.58	14.51	-13.03	3.66	-20.05	10.34
ADT 43 x IR 20	-12.96	-12.96	-15.07	-9.44	-12.94	-12.94	-0.40	-0.40	78.36	80.08	-19.87	37.01	6.73	13.72	-12.75	-12.75	13.20	30.07	26.18	26.18	-11.99	6.29
NLR 34449 x ADT 37	-4.02	-12.02	-7.33	-6.53	23.77	41.21	3.83	28.91	10.84	35.70	27.52	72.70	-1.61	-15.28	-32.99	-17.71	-2.48	3.01	-16.07	2.97	-1.77	47.54
NLR 34449 x ADT 45	14.18	4.67	-2.66	-7.41	21.99	44.13	8.87	26.87	-10.60	3.00	15.42	52.87	0.14	19.61	-2.66	-11.90	2.78	35.42	-2.90	16.93	-3.20	37.18
NLR 34449 x IR 36	-2.05	-10.21	-29.63	-28.79	2.31	38.53	-41.77	-18.45	-6.92	22.09	30.20	68.03	-19.66	-1.00	42.02	19.69	-27.39	6.01	-23.43	-8.73	-17.24	14.22
NLR 34449 x IR 20	-8.39	-8.39	-12.52	-12.52	22.20	22.20	-7.19	-7.19	45.87	59.49	33.23	42.59	-11.28	-11.28	26.49	26.49	-27.60	-23.53	15.04	17.45	28.88	32.28
AKSHYA x ADT 37	-4.45	5.16	-19.89	-19.19	-32.31	-22.78	-32.60	-16.32	-0.96	21.26	2.85	75..34	0.72	-14.94	-18.92	-0.42	-47.09	-14.51	-6.12	15.18	-13.71	29.61
AKSHYA x ADT 45	-7.64	1.66	-3.63	-11.11	0.79	19.08	20.37	40.27	-6.77	7.41	-22.25	32.56	-14.51	2.11	-7.82	-16.57	-24.35	22.22	-39.13	-26.70	-6.55	32.43
AKSHYA x IR 36	-0.24	9.80	-24.50	-23.60	-16.10	13.60	-12.63	22.38	-10.53	17.35	-16.13	42.99	-25.20	-7.83	-2.02	-17.42	-31.07	11.37	-13.03	3.66	-22.77	6.58
AKSHYA x IR 20	-2.56	7.25	-31.63	-31.63	38.50	38.50	18.73	18.73	48.70	70.96	-14.74	45.36	-1.44	-1.44	-24.36	-24.36	-19.42	30.20	21.64	21.64	21.00	28.32
PONNI x ADT 37	-5.48	0.62	-29.91	-4.37	-13.04	-0.79	-18.59	1.08	41.94	73.77	17.80	59.54	10.63	13.89	-26.41	-9.63	2.88	25.88	-5.55	15.88	0.47	50.90
PONNI x ADT 45	-8.12	-2.19	-27.99	-1.75	-7.12	9.74	-31.90	-20.64	6.10	22.24	14.27	51.35	-13.81	2.94	-2.19	-11.47	-11.81	16.21	-35.36	-22.16	-2.58	38.06
PONNI x IR 36	-10.56	-4.79	-23.43	4.47	-18.06	10.95	-1.00	38.67	-5.20	24.34	31.62	69.86	-8.61	12.61	33.28	12.32	-31.42	0.13	-27.82	-13.96	-9.90	24.35
PONNI x IR 20	-2.08	4.24	-32.49	-7.89	14.72	14.72	-1.56	-1.56	10.26	15.80	15.80	24.01	18.51	22.00	20.82	20.82	-17.74	0.65	16.75	16.75	31.25	55.05
ADT-39 x ADT 37	-2.22	-22.16	-31.62	-31.03	-2.02	46.62	2.99	49.55	-15.96	18.67	-19.17	45.50	12.63	16.39	-12.34	7.65	-7.72	7.84	-22.90	-5.41	-19.81	20.45
ADT-39 x ADT 45	-4.26	-25.33	-21.33	-27.44	26.96	89.98	30.01	88.80	37.33	93.93	13.91	105.04	3.12	23.17	17.37	6.23	-5.95	23.92	2.17	23.04	16.48	65.07
ADT-39 x IR 36	-9.05	-19.66	-12.09	-11.04	-0.68	48.61	3.25	49.94	-10.83	25.93	-5.46	70.18	-12.22	8.17	26.16	11.33	-33.57	-3.01	-19.91	-4.54	-26.27	1.75
ADT-39 x IR 20	-23.39	-23.39	-29.36	-29.36	-6.78	39.48	29.74	88.41	-19.38	13.85	-4.18	42.49	11.56	15.28	17.85	17.85	-16.55	-2.48	2.06	20.77	-17.63	6.44
KULLAKAR x ADT 37	-2.93	-22.73	-35.38	-34.82	-21.02	44.83	-24.59	40.30	-32.56	3.68	-45.78	25.11	5.69	22.89	-3.58	22.24	6.00	-3.01	-7.77	16.06	-18.53	26.81
KULLAKAR x ADT 45	-7.61	-27.35	-31.33	-36.66	-52.03	-12.03	-54.91	-16.11	-30.62	6.67	-51.05	12.95	-3.40	15.39	-10.06	14.02	-23.31	1.05	-4.58	20.07	-25.13	16.52
KULLAKAR x IR 36	-15.28	-25.16	-30.02	-29.09	4.29	91.25	2.18	90.11	13.42	74.38	-11.53	104.16	-3.47	18.94	-0.78	25.78	-35.36	-5.62	11.23	39.97	11.20	73.08
KULLAKAR x IR 20	-30.71	-30.71	-29.09	-29.09	-3.79	76.43	-28.53	32.98	-21.44	20.79	-53.37	7.60	-0.05	16.22	-22.46	-1.70	18.04	18.04	-3.19	21.82	-24.67	17.25
ASHWANI x ADT 37	5.44	-16.06	-21.63	-20.95	8.25	37.97	28.19	59.17	31.19	88.47	-6.32	70.99	6.33	23.11	-11.39	10.20	19.80	11.50	-1.85	20.42	14.89	73.03
ASHWANI x ADT 45	0.68	-21.48	-25.87	-31.63	15.48	47.18	29.15	50.51	33.34	91..57	-12.53	59.65	6.28	26.94	-20.16	-0.71	-3.08	27.71	10.72	33.33	6.46	60.33
ASHWANI x IR 36	-8.05	-18.78	0.13	1.33	6.64	44.40	1.87	42.69	-14.85	22.34	-10.20	63.91	-7.35	14.17	-12.76	8.50	-27.93	5.23	-8.05	9.60	-0.48	49.87
ASHWANI x IR 20	-24.74	-24.74	-28.01	-28.01	6.69	35.99	18.41	35.69	-23.65	9.69	-13.54	57.80	0.86	16.78	-1.37	22.66	-5.10	-5.10	12.08	23.04	-5.63	42.13
GIRI x ADT 37	14.09	2.64	-18.88	-18.18	26.19	43.96	3.21	28.15	-3.89	17.67	36.64	85.05	5.34	20.44	-11.30	8.92	-3.21	10.46	-12.66	7.16	4.10	56.36
GIRI x ADT 45	11.83	0.60	-2.54	-10.11	26.61	49.59	-15.92	-2.01	1.67	17.14	19.09	57.73	1.63	21.39	8.14	-2.12	-6.05	23.79	-21.74	-5.76	11.90	58.57
GIRI x IR 36	17.35	5.57	-11.32	-10.87	19.41	61.68	-2.67	36.32	-9.26	19.01	25.00	61.32	-2.61	20.00	31.86	18.41	-30.71	1.18	1.90	21.47	7.26	48.02
GIRI x IR 20	3.73	3.73	-30.10	-30.10	40.90	56.65	26.81	29.50	21.57	34.11	47.86	50.87	10.16	25.94	19.55	19.55	17.30	33.86	22.34	22.34	22.09	32.65

*significant at 5% level ** significant at 1% level dii= Heterobeltiosis, diii= Standard heterosis.

Among the thirty two hybrids, Fourteen hybrids exhibited positively significant heterobeltiosis for number of grains per panicle which ranged from 2.85 to 47.86 per cent. GIRI × IR 20 (47.86 per cent) recorded the maximum significant positive value. For standard heterosis, all thirty two hybrids were showed significantly positive values. ADT-39 × ADT 45 (105.04 per cent) followed by KULLAKAR × IR 36 (104.16 per cent) recorded the maximum positive significant values. The similar result findings of Ammer Gholizadeh Ghara *et al.* (2014) and Nainu *et al*. (2016).

For kernel length out of thirty two hybrids studied fourteen hybrids showed significant and positive heterobeltiosis and ranged from 0.86 to 11.56 per cent. The maximum heterobeltiosis was recorded by ADT-39 × IR 20 (11.56 per cent). The standard heterosis for this trait was positively significant for twenty six hybrids and it ranged from 2.11 to 26.94 per cent. Cross ASHWANI × ADT 45 (26.94 per cent) showed the maximum standard heterosis value and this was followed by GIRI x IR 20 (25.94 per cent).

Among the hybrids, twelve hybrids recorded significant and positive heterobeltiosis for kernel breadth. The maximum value was recorded by NLR 34449 × IR 20 (42.02 per cent) followed by ADT 43 × ADT 45 (35.99 per cent). Out of thirty two hybrids studied, nineteen hybrids registered significant and positive standard heterosis and it ranged from 6.23 to 26.49 per cent. The maximum positive and significant value was recorded by NLR 34449 × IR 20 (26.49 per cent) followed by ADT 43 × ADT 45 and KULLAKAR × IR 36 (25.78 per cent).

For kernel L/B ratio, four hybrids recorded significant and positive heterobeltiosis for this trait out of which maximum value was recorded by ASHWANI × ADT 37 (19.80 per cent) followed by KULLAKAR x IR 20 (18.04 per cent). Out of thirty two hybrids studied, sixteen hybrids recorded significant and positive standard heterosis. Cross NLR 34449 × ADT 45 (35.42 per cent) followed by GIRI × IR 20 (33.86 per cent) showed positive and significant value for this trait.

For hundred grain weight the magnitude of positively significant heterobeltiosis for eight crosses. The maximum significant and positive heterobeltiosis was observed in ADT 43 × IR 20 (26.18 per cent) followed by GIRI × IR 20 (22.34 per cent). Standard heterosis was observed to be significant and positive in twenty crosses, which were ranged from 7.16 to 39.97 per cent. The maximum positive and significant value was noticed in the cross KULLAKAR × IR 36 (39.97 per cent) followed by ASHWANI × ADT 45 (33.33 per cent). These results are similar with the findings of Nainu *et al*. (2016).

For grain yield per plant, a total of eleven hybrids exhibited significantly positive heterobeltiosis where, the maximum significant and positive value was noticed in the cross PONNI × IR 20 (31.25 per cent) followed by NLR 34449 × IR 20 (28.88 per cent). In case of standard heterosis, thirty hybrids are recorded the positively significant values. The maximum positive significant was observed in KULLAKAR × IR 36 (73.08) and this was followed by ASHWANI × ADT 37 (73.03 per cent). The similar results findings of Abdel Moneam *el al.* (2016).

Conclusion

The magnitude of heterobeltiosis and standard heterosis were high significant for grain yield per plant in almost crosses, Based on standard heterosis, the hybrids KULLAKAR × IR 36, ASHWANI × ADT 37, ADT 39 × ADT 45 and ASHWANI × ADT 45 also recorded significantly high standard heterosis for grain yield and most of its associated traits. The hybrids, KULLAKAR × IR 36 and ASHWANI × ADT 37 were recorded with high *per se* performance, highly significant *sca* effects and high standard heterosis for grain yield and its component traits were found to be suitable for heterosis breeding.

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