Electronic Journal of Plant Breeding (2009) 1: 18-23

Research Article

Combining ability of rice genotypes under coastal saline soils

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Abstract
Six lines and five testers were crossed in line x tester fashion and the F_1s were evaluated under coastal saline situation. The ratio between the estimates of additive and dominance variances indicated preponderance of non-additive gene action for the characters namely, plant height, number of productive tillers, boot leaf length, panicle length, grain weight per primary panicle and grain yield per plant. Among the parents, IR 65847-3B-6-2 recorded significantly superior grain yield per plant and panicle length. Parent IR 65192-4B-8-1 recorded superior mean for boot leaf length, panicle length and grain weight per panicle. Among the lines IR 65847-3B-6-2 and IR 65192-4B-8-1 showed good combining ability for grain yield per plant, panicle length and grain weight per panicle. It indicates the existence of good relationship between *per se* performance and *gca* effects of parents. Among the hybrids, IR 65847-3B-6-2 X Vandana, IR 65847-3B-6-2 X ADT 45, IR 65847-3B-6-2 X Norungan, IR 65847-3B-6-2 x MDU 5, IR 65847-3B-6-2 X PMK 2, IR 65192-4B-8-1 X Vandana, IR 65192-4B-8-1 X ADT 45, IR 65192-4B-8-1 X Norungan, IR 65192-4B-8-1 X MDU 5 and IR 65192-4B-8-1 X PMK 2 recorded significantly superior grain yield per plant and grain weight per primary panicle. With regard to specific combining ability effects, all these hybrids recorded additive gene action except IR 65847-3B-6-2 X ADT 45. The hybrids IR 65847-3B-6-2 X ADT 45 recorded non additive gene action especially of dominance X dominance type. Hence these crosses can be subjected to pedigree breeding to evolve high yielding genotypes suitable for coastal saline soils.
Key words: Rice, salinity, combining ability, gene action.

Introduction

Rice is an important cereal crop in India. It is grown mainly in tropical and subtropical zones. The productivity of rice is being affected by biotic and abiotic factors. Among the various abiotic factors, salinity is an important yield limiting factor in coastal saline areas. The abiotic stress can induce floret sterility and limit grain yield (Osada *et al*., 1973; Satake and Yoshida, 1978; Matsushima *et al*., 1982). Hence, it is necessary to evolve saline tolerant and high yielding varieties of rice for the coastal saline areas. Line x tester analysis has been widely used by plant breeders to assess the combining ability of parents. This analysis provides valuable information on the nature of gene action, in addition to the combining ability of parents and hybrids. In the present study an attempt was made to assess the combining ability of 11 rice genotypes and their 30 hybrids under coastal saline situation.

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Materials and Methods

Six lines namely, IR 66, IR 5931-110-1, ASD 20, IR 65847-3B-6-2, IR 65192-4B-8-1 and IR 58190-40-3-1-2 based on diversity analysis and five varieties namely, Vandana, ADT 45, Norungan, MDU 5 and PMK 2 of Tamil nadu were selected as testers and crossed in line x tester fashion. The30 F_1s and 11 parents were evaluated in replicated trial adopting RBD design under coastal saline condition. The experiment was conducted at Plant Breeding Farm, Department of Agriculture Botany, Faculty of Agriculture, Annamalai University, Annamalainagar during July-Oct. 2007. The experimental field was under natural coastal saline condition with pH of 7.8 and EC range of 4.3 to 5.5 dSm^{-1}. Twenty three days old seedlings were transplanted to the main field at the rate of one seedling per hill with the spacing of 30 cm between rows and 20 cm within plants. Observations were recorded for plant height, number of productive tillers, boot leaf length, panicle length, grain weight per panicle and grain yield per plant on five plants per replication per entry. The data were subjected to line x tester analysis as suggested by Kempthrone (1957).

Results and Discussion

The analysis of variance for combining ability revealed the existence of significant differences among lines and testers for combining ability effects in all characters (Edwin Rogbell and Subbaraman, 1997) except for grain yield per plant. For grain yield per plant, significant differences of combining ability effects were observed among lines alone (Table 1). With regard to specific combining ability effects, significant differences were observed for all characters except for plant height and productive tillers. The variances due to the estimates of additive and non additive components indicated the predominance of dominance gene action for all the characters indicating the usefulness of heterosis breeding for the improvement of these characters. This stresses the need for exploiting *sca* variance to obtain high yielding combination and also indicates a predominantly non-additive and also indicates a predominantly non-additive type of genetic component governing these characters (Edwin Rogbell and Subbaraman, 1997). Ram e*t al.,* (1991) also found high magnitude of specific combining ability variance for all these characters. Predominance of additive gene action was reported by Lavanya (2000), Kalitha and Upadhaya (2000), Bidhan Roy and Mandal (2001) for plant height; Kalitha and Upadhaya (2000) for Noumber of productive tillers; Kalitha and Upadhaya (2000), Lavanya (2000) for panicle length and Lavanya (2000), Sathyanarayanan *et al.* (2000), Bidhan Roy and Mandal (2001) for grain yield/ plant. However more of non additive gene action was reported by Acharya *et al.,* (2000), Munhot *et al.* (2000), Sathyanarayanan *et al.* (2000) for plant height; Saravanan (2000) for Number of productive tillers; Munhot *et al.* (2000) Acharya *et al.* (2000), Sathyanarayanan *et al.* (2000), Bidhan Roy and Mandal (2001) for panicle length and Acharya *et al.* (2000), Annadurai and Nadarajan (2001) and for grain yield per plant.

The first and foremost criterion for the choice of parents is the *per se* performance. Among the parents, IR 65847-3B-6-2 alone recorded significantly superior grain yield per plant. This was followed by IR58190-40-3-1-2, IR 5931-110-1 and IR 65192-4B-8-1. Parents IR 65847-3B-6-2, IR 5931-110-1 and IR 65192-4B-8-1 also recorded superior performance for 100 grain weight, grain weight per panicle and panicle length respectively. Parent IR 65192-4B-8-1 recorded superior *per se* for boot leaf length, panicle length and grain weight per panicle. The testers namely, Vananda, ADT 45 and Norungan were alone recorded superior performance for number of productive tillers. The desirable plant height was recorded by ASD 20 and IR 66. Among the parents IR 5931-110-1 and MDU 5 alone recorded superiority for grain weight per panicle. Hence based on the *per se* performance the parents IR 65847-3B-6-2, IR 5931-110-1, IR 58190-40-3-1-2 and IR 65192-4B-8-1 were considered as superior (Table 2).

The general combining ability effects of parents is another important factor. Among the parents IR 65847-3B-6-2 and IR 65192-4B-8-1 recorded desirable combining ability effects for grain yield per plant, panicle length and grain weight per panicle. The parents IR 5931-110-1 recorded desirable combining ability for plant height and productive tillers per plant. The line parent IR 58190-40-3-1-2 recorded desirable combining ability effects for no. of productive tillers per plant, boot leaf length and grain weight per panicle. Among the tester parents, Vandana for boot leaf length; ADT 45 for panicle length; Norungan for number of productive tillers per plant and boot leaf length; MDU 5 for plant height and PMK 2 for no. of productive tillers per plant recorded desirable *gca* effects. Considering the *per se* and *gca* effects together, the parents IR 65847-3B-6-2 and IR 65192-4B-8-1 were considered as desirable parents. It may also be noted that the good combiners namely, IR 65847-3B-6-2 and IR 65192-4B-8-1 also recorded superior *per se* performance for many of the traits. The cross combinations had high heterosis and the parents of these crosses were good general combiners. Such results might be due to interaction of dominant genes contributed by the parents (Edwin Rogbell and Subbaraman, 1997). Hence, the superior *per se* performing parents are also expected to have desirable combining ability effects to yield contributing characters (Table 3).

The *per se* performance was the first criterion in the choice of hybrids. Among the crosses, IR 65847-3B-6-2 X Vandana, IR 65847-3B-6-2 X ADT 45, IR 65847-3B-6-2 X Norungan, IR 65847-3B-6-2 X MDU 5, IR 65192-4B-8-1 X Vandana, IR 65192-4B-8-1 X ADT 45, IR 65192-4B-8-1 X Norungan, IR 65192-4B-8-1 X MDU 5 and IR 65192-4B-8-1 X PMK 2 recorded superior grain yield per plant and grain weight per panicle (Table 4). In general, high mean and average combiners produce high yielding hybrids. This might be due to additive gene action. The second criterion in the choice of hybrid is the specific combining ability effects. In the present study, all the superior hybrids recorded additive gene action except IR 65847-3B-6-2X ADT 45 for which additive type epistasis observed (Table 5). Hence these crosses can be selected for pedigree breeding to evolve high yielding genotypes for coastal saline situations. The parents IR 65847-3B-6-2 and IR 65192-4B-8-1 are good combiners and can be used in saline tolerance breeding.

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Table. 1 Mean of parents for various characters in rice

Parents	Plant height (cm)	No. of Productive tillers	Boot leaf length (cm)	Panicle length (cm)	Grain weight / panicle (g)	100 grain weight (g)	Grain yield / plant (g)
Lines							
IR 66	46.8*	10.0	20.8	23.1	2.8	2.7	24.1
IR 5931-110-1	73.1	10.1	17.0	19.0	3.4*	2.6*	33.2
ASD 20	48.0*	22.8	22.1	23.1	2.0	2.2	31.1
IR 65847-3B-6-2	68.4	15.2	28.8	23.0*	2.4	2.8	36.0*
IR 65192-4B-8-1	115.2	9.8	38.3*	24.9*	3.3*	2.5*	33.2
IR 58190-40-3-1-2	123.2	11.3	27.1	22.8*	2.1	2.6	34.9
Testers							
Vandana	125.4	30.0*	27.1	22.0	2.9	2.5	25.2
ADT 45	128.8	29.3*	26.1	23.5*	2.6	2.4	23.9
Norungan	122.6	27.2*	28.2	23.1	2.2	2.2	25.0
MDU 5	87.8	13.0	27.1	19.0	3.5*	2.3*	26.2
PMK 2	68.9	12.9	25.5	21.8	2.2	2.4	25.9
S.E.	4.2	2.2	2.1	0.9	0.1	0.1	0.9
C.D. (P=0.05)	13.1	4.1	5.8	2.5	0.2	0.2	2.6

* Significantly superior

Table 2. General combining ability effects of parents

Parents	Plant height (cm)	No. of Productive tillers	Boot leaf length (cm)	Panicle length (cm)	Grain weight/ panicle (g)	100 grain weight (g)	Grain yield/ plant (g)
Lines							
IR 66	-7.9**	-3.0**	5.1**	1.6**	-0.19**	-0.12**	-2.1**
IR 5931-110-1	-7.8**	3.2**	-4.1**	-0.3	-0.11**	-0.04**	-0.2
ASD 20	-11.9**	2.6**	-5.8**	-1.3**	-0.03	-0.02	-1.9**
IR 65847-3B-6-2	-2.2	-2.2*	-7.3**	1.4*	0.14**	0.13**	1.8**
IR 65192-4B-8-1	12.3**	-2.7**	1.6	1.6**	0.11**	-0.09	1.9**
IR 58190-40-3-1-2	17.3**	1.7*	10.2**	-2.4**	0.17**	-0.09*	0.3
S.E. (Lines)	2.4	0.8	1.0	0.3	0.02	0.02	0.3
Testers							
Vandana	4.0	-0.7	2.8**	0.4	-0.06*	-0.06	0.4
ADT 45	7.2**	-6.2**	-2.1*	1.4**	-0.03	-0.03	-0.3
Norungan	0.1	5.9**	5.8**	0.9	0.03	0.04	-0.1
MDU 5	-8.0**	-1.3*	-3.3**	-1.1*	0.04	0.06	0.2
PMK 2	-2.8	2.4**	-3.4**	-1.3**	0.03	0.05	0.4
S.E. (Testers)	2.2	0.7	1.2	0.4	0.02	0.03	0.3

*,** significant at 5 and 1 per cent respectively

Table 3. Mean performance of crosses for various characters in L X T analysis

Cross	Plant height (cm)	Number of productive tillers / plant	Boot leaf length (cm)	Panicle length (cm)	Grain weight per panicle (g)	100 grain weight (g)	Grain yield per plant (g)
L1 x T1	125.02	33.21	55.89	32.31	2.23	2.43	28.23
L1 x T2	124.82	31.32	41.75	32.98	2.49	2.58	28.94
L1 x T3	122.12	34.79	62.35	29.89	2.59	2.68	29.39
L1 x T4	92.08	22.56	32.49	26.59	2.68	2.51	27.97
L1 x T5	98.44	31.76	29.58	24.65	2.58	2.64	30.13
L2 x T1	131.12	33.43	38.36	28.95	2.58	2.35	30.91
L2 x T2	122.01	33.25	30.97	28.57	2.64	2.46	30.69
L2 x T3	107.92	47.34	46.21	27.91	2.58	2.57	30.79
L2 x T4	105.23	31.25	33.18	26.24	2.64	2.56	30.58
L2 x T5	96.31	40.14	26.12	22.59	2.52	2.35	31.92
L3 x T1	120.10	37.34	31.34	27.69	2.61	2.51	29.87
L3 x T2	99.12	29.89	20.82	20.98	2.65	2.48	29.38
L3 x T3	112.51	45.89	42.28	27.79	2.54	2.57	29.29
L3 x T4	93.58	38.51	35.97	27.61	2.60	2.35	29.64
L3 x T5	115.34	27.64	36.59	28.76	2.63	2.46	28.98
L4 x T1	113.93	21.24	27.38	25.21	2.73	2.79	34.29
L4 x T2	123.42	21.94	32.23	29.23	2.70	2.59	34.92
L4 x T3	115.21	38.36	32.49	30.86	2.73	2.67	33.38
L4 x T4	119.25	38.45	34.35	28.38	2.72	2.58	31.66
L4 x T5	118.92	40.24	31.89	29.50	2.74	2.67	33.22
L5 x T1	122.57	31.19	45.39	30.20	2.70	2.59	33.82
L5 x T2	154.91	38.56	54.79	32.50	2.68	2.67	32.91
L5 x T3	131.43	29.65	30.25	26.58	2.73	2.58	32.96
L5 x T4	117.95	26.12	35.46	27.09	2.63	2.67	32.79
L5 x T5	134.83	30.49	37.34	29.79	2.70	2.68	32.74
L6 x T1	130.00	41.25	50.21	22.89	2.67	5.56	32.64
L6 x T2	139.34	10.49	40.92	29.34	2.55	2.65	28.95
L6 x T3	131.32	38.38	55.08	24.28	2.72	2.48	32.68
L6 x T4	144.19	37.89	45.48	24.40	2.70	2.49	32.92
L6 X T5	140.40	46.18	53.45	24.81	2.72	2.76	32.95
S.E.	5.05	1.61	2.24	0.91	0.05	0.04	0.68
C.D (P=0.05)	14.63	4.66	6.49	2.64	0.15	0.20	1.98
C.D (P=0.01)	19.70	6.27	8.74	3.55	0.02	0.02	2.66

L1- IR 66, L2 – IR 5931-110-1, L3 – ASD 20, L4 – IR 65847-3B-6-2, L5 - IR 65192-4B-8-1, L6 – IR 58190-0-3-1-2.

T1 – Vandana, T2 –ADT 45, T3 – Norungan, T4 – MDU 5, T5 – PMK 2.

Table 4. Specific combining ability effects of crosses for various characters in rice

Cross	Plant height (cm)	Number of productive tillers/ plant	Boot leaf length (cm)	Panicle length (cm)	Grain weight per panicle(g)	100grain weight (g)	Grain yield per plant (g)
L1 x T1	9.34	2.43	9.65**	2.67*	-0.22**	-0.21	-1.36
L1 x T2	4.80	6.66**	-0.32	1.28	-0.03	-0.04	0.50
L1 x T3	9.97	-1.54	12.66**	1.34	-0.02	-0.03	0.55
L1 x T4	-11.34*	-6.45**	-9.95**	-1.49	0.12*	0.21*	-0.51
L1 x T5	-10.83*	-1.36	-12.65**	-3.35**	0.15*	0.21*	1.01
L2 x T1	14.75**	-2.89	1.38	2.32*	-0.01	-0.13	-0.23
L2 x T2	2.28	2.79	-2.12	0.51	0.02	0.02	0.45
L2 x T3	-4.30	4.86**	5.38*	1.14	0.05	0.06	-0.36
L2 x T4	1.23	-5.98**	1.27	-0.31	0.04	0.18	1.45
L2 x T5	-14.13*	1.42	-5.86*	-3.23**	-0.08	-0.09	-0.46
L3 x T1	8.34	2.68	-4.48	1.42	0.07	-0.18	-0.49
L3 x T2	-16.34**	1.12	-10.46**	-6.46**	0.04	0.16	0.41
L3 x T3	4.67	4.56*	2.24	1.24	-0.06	0.05	-0.54
L3 x T4	-6.85	4.75*	5.79*	1.48	-0.03	-0.19	0.15
L3 x T5	9.68	-10.65**	6.73**	2.78**	-0.04	-0.06	-0.52
L4 x T1	-7.89	-9.46**	-7.34**	-3.69**	0.06	0.08	1.20
L4 x T2	-1.74	-4.78**	2.56	-0.45	0.02	0.13	1.56*
L4 x T3	-3.34	1.28	-4.68	1.68	-0.04	0.18	-0.46
L4 x T4	9.54	7.27**	4.89*	0.99	-0.05	-0.06	-1.86*
L4 x T5	3.28	5.67**	4.58*	1.48	-0.03	-0.04	-0.58
L5 x T1	-13.91*	0.92	2.57	0.36	0.07	0.06	0.51
L5 x T2	15.89**	14.24**	16.32**	2.51*	0.05	0.08	0.24
L5 x T3	-2.66	-6.70**	-15.85**	-3.87**	0.02	0.07	-0.58
L5 x T4	-6.87	-4.31*	-2.86	-0.88	-0.06	-0.07	0.49
L5 x T5	5.68	-3.51*	-0.86	1.68	-0.02	0.02	-0.89
L6 x T1	-10.59*	6.89**	-1.37	-2.57*	0.04	0.03	0.56
L6 x T2	-5.58	-18.61**	-6.28*	2.89**	-0.08	-0.07	-2.74**
L6 x T3	-5.67	-2.24	0.39	-1.71	0.06	0.05	0.29
L6 x T4	15.78**	5.24**	-0.48	0.21	0.02	0.03	0.89
L6 X T5	6.59	8.93**	7.53**	0.99	0.03	0.2	1.23
S.E.	5.05	1.61	2.24	0.91	0.05	0.04	0.68

*,** significant at 5 and 1 per cent respectively.

L1- IR 66, L2 – IR 5931-110-1, L3 – ASD 20, L4 – IR 65847-3B-6-2, L5 - IR 65192-4B-8-1, L6 – IR 58190-40-3-1-2.

T1 – Vandana, T2 –ADT 45, T3 – Norungan, T4 – MDU 5, T5 – PMK 2.