Combining ability studies of Rice Genotypes in different seasons under saline conditions

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Abstract- *Forty Five single crosses without reciprocals in 10 x 10 full diallel were attempted during rabi 2010 and the F1 were evaluated in different seasons under coastal saline situations. The mean squares due to gca and sca were found significant for all traits across the seasons. In general the parents MTU 1061 and MTU 1001 were noticed to be good general combiners in all the seasons for grain yield and majority of yield component characters studied in the present investigation. Among the hybrids, NLR 33359 x MTU 1001, NLR 40024 x MTU 1061 and NLR 40024 x MTU 1001 were noticed to be good specific combiners across all the seasons studied with regards to yield components and grain yield indicating their potentials as promising hybrids for saline conditions. Hence, these crosses can be subjected to pedigree breeding to evolve high yielding genotypes suitable for coastal saline soils.*

Keywords:- Combining ability, Rice, Salinity, Seasons.

I. INTRODUCTION

Soil salinity is one of the major abiotic stresses affecting the productivity of rice crop in the coastal regions of the country. In India of the total 8.5 M.ha. of land which is affected by soil salinity, about 2.10 M.ha area is affected with coastal salinity. The yield reduction of rice due to soil salinity is estimated to be around 30-50%.

Rice (Oryza Sativa L.) is an important cereal food crop in India and Andhra Pradesh. The demand for rice is increasing as the population is increasing day by day. Therefore, increasing the yield of rice in poor soils and in less productive saline soils is essential for feeding the growing population.

Selection of suitable parents is important in a breeding programme, particularly if the aim is to improve a quantitative character such as yield. Therefore, gathering information on the nature of gene effects and their expression in terms of combining ability of the parents is necessary.

II. MATERIAL AND METHODS

In the present investigation ten genotypes viz., NLR-3041, NLR-33358, NLR-33359, NLR-40024, NLR-33671, NLR-33057, BPT-2231, MTU-1061, MTU-1001 and PUSA-1121 were selected as parents based on D2 statistic. 45 single crosses without reciprocals in 10 x10 full-diallel were attempted. The experiment was conducted in 2 environments each in kharif and rabi seasons of 2011. Each season is further divided in to normal and late sowing situations prevailing in Agricultural Research Station, Machilipatnam, Krishna District depending on the release of canal water. Accordingly, the parents and their 45 F1 hybrids were studied in these 4 environments viz., Normal Kharif, Late Kharif in 2011, Normal rabi 2011-12 and Late rabi, 2012. The Statistical analysis for estimating the combining ability was carried out as per model I and method II (F1s + parents) (fixed effects) of Griffing (1956a)

III. RESULTS AND DISCUSSION

The mean squares due to gca, sca and their interactions with seasons for different characters studied is presented in Table 1. Mean squares due to gca and sca were found significant for all traits across the seasons. These results revealed the importance of both additive and non-additive gene actions for different traits studied during the four seasons. Further variance ratio of gca:sca indicated the pre-dominant role of non-additive gene action for all characters studied in the present investigation. Similar pre-ponderant role of non-additive gene action for days to 50 per cent flowering (Jayasudha and Deepak Sharma, 2010, Kumar Babu et al. 2010 and Saidaiah et al. (2010a), plant height (Sanjeev Kumar et al. 2009 and Karthikeyan et al. 2009), productive tillers hill-1 (Salgotra et al. 2009 and Jayasudha and Deepak Sharma, 2010), spikelet fertility percentage (Bisne and Motiramani, 2005 and Senguttuvel, 2008), 1000 seed weight (Shukla and Pandey, 2008) and grain yield plant-1 (Dalvi and Patel, 2009, Salgotra et al. 2009 and Kumar Babu et al. 2010).

General Combining Ability Effects

The general combining ability effects (gca) for various characters studied in different seasons in the present investigation are presented in Table 2.

3.1.1 Days to 50 percent flowering

During normal kharif four parents had recorded significant gca effects in desired direction for the trait and hence, were identified as good combiners for days to 50 percent flowering. In late kharif significant gca effects in desired direction was recorded for this trait in NLR33057, NLR33358, NLR33359 and NLR40024 and hence, were identified as good combiners for days to 50 percent flowering during the season. The estimates of gca effects were significant and negative for NLR33358, NLR33359, NLR40024, NLR33671 and MTU1001 and hence, were identified as good combiners for days to 50 percent flowering during the season. During late rabi, Significant and negative gca effects desirable for the trait were noticed in NLR33057, NLR33358, NLR33359, NLR40024, NLR33671 and MTU1001 and hence, were identified as good combiners for days to 50 percent flowering during the season.

3.1.2 Plant height (cm)

In normal kharif two parents, namely, NLR3041 and PUSA1121 had recorded significant gca effects in desired direction for the trait and hence, were identified as good combiners for plant height. During late kharif, significant gca effects in desired direction was recorded for this trait in NLR40024, NLR3041 and NLR33671 and hence, were identified as good combiners for plant height during the season. The estimates of gca effects were significant and negative for NLR33358, NLR40024, NLR3041 and PUSA1121 and hence, were identified as good combiners for plant height during normal rabi season. During late rabi, Significant and negative gca effects desirable for the trait were noticed in NLR33358, NLR40024, NLR3041 and PUSA1121 and hence, were identified as good combiners for plant height during the season. High gca effects for this trait was reported by Pradhan and Singh (2008).

3.1.3 No. of productive tillers hill-1

The grain yield of any variety mainly depends on the contribution of yield determining characters and among them, the number of productive tillers per hill is very important. Plant types with higher number of productive tillers usually produce higher yields.

During normal kharif, three parents (MTU1061, MTU1001 and BPT2231) had recorded positive and significant gca effects for the trait and hence, were identified as good combiners for productive tillers hill-1. In late kharif, significant gca effects in desired direction was recorded for this trait in NLR40024, NLR3041, MTU1061 and MTU 1001 and hence, were identified as good combiners for productive tillers hill-1 during the season.

In normal rabi, the estimates of gca effects were significant and positive for NLR33359, NLR40024, MTU1061 and MTU1001 and hence, were identified as good combiners for productive tillers hill-1 during the season. During late rabi, four parents (NLR33359, NLR40024, MTU 1061 and MTU 1001) had recorded positive and significant gca effects for the trait and hence, were identified as good combiners for productive tillers hill-1 during the season. High gca effects for this trait was reported by Pradhan and Singh (2008).

3.1.4 Spikelet fertility

During normal kharif, three parents (MTU1061, MTU1001 and BPT2231) had recorded positive and significant gca effects for the trait and hence, were identified as good combiners for spikelet fertility percentage. In late kharif, significant gca effects in desired direction was recorded for this trait in NLR33057, NLR40024, MTU 1001 and MTU1061 and hence, were identified as good combiners for spikelet fertility percentage during the season.

Among the parents in normal rabi, the estimates of gca effects were significant and positive for MTU1061and MTU1001 and hence, were identified as good combiners for spikelet fertility percentage during the season. During late rabi, four parents (NLR33359, NLR40024, MTU 1061 and MTU 1001) had recorded positive and significant gca effects for the trait and hence, were identified as good combiners for spikelet fertility percentage during the season. High gca effects for this trait was reported by Pradhan and Singh (2008).

3.1.5 1000 seed weight (g)

During normal kharif, three parents (MTU1061, MTU1001 and BPT2231) had recorded positive and significant gca effects for the trait and hence, were identified as good combiners for 1000 seed weight. In late kharif, significant gca effects in desired direction was recorded for this trait in MTU 1061, MTU1001 and BPT2231 and hence, were identified as good combiners for 1000 seed weight during the season.

Among the parents in normal rabi, the estimates of gca effects were significant and positive for NLR33057, NLR33358, NLR33359, NLR33671, MTU1061, MTU1001 and BPT2231 and hence, were identified as good combiners for 1000 seed weight during the season. During late rabi,

seven parents (NLR33057, NLR33358, NLR33359, NLR333671, MTU 1061, MTU 1001 and BPT2231) had recorded positive and significant gca effects for the trait and hence, were identified as good combiners for 1000 seed weight during the season.

3.1.6 Grain yield plant-1 (g)

During normal kharif, three parents (MTU1061 and MTU1001 and BPT2231) had recorded positive and significant gca effects for the trait and hence, were identified as good combiners for grain yield plant-1. In late kharif, significant gca effects in desired direction was recorded in NLR40024, MTU 1061 and MTU1001 and hence, were identified as good combiners for g grain yield plant-1 during the season. Among the parents in normal rabi, the estimates of gca effects were significant and positive for NLR33358, NLR33359, NLR40024, MTU1061 and MTU1001 and hence, were identified as good combiners for grain yield plant-1 during the season.

During late rabi, three parents (NLR33359, MTU 1061 and MTU 1001) had recorded positive and significant gca effects for the trait and hence, were identified as good combiners for grain yield plant-1 during the season. High gca effects for this trait was reported by Pradhan and Singh (2008).

In general, MTU 1061 and MTU 1001 were noticed to be good general combiners in all the seasons for grain yield and majority of yield component characters studied under saline conditions in the present investigation, indicating their potential in development of high yielding varieties with resistance to salinity. Further, BPT 2231 was noticed to be a good general combiner for grain yield, productive tillers hill-1, spikelet fertility per cent and 1000 seed weight during normal kharif, while NLR 40024 was noticed to be a good general combiner for grain yield, days to 50 per cent flowering, plant height and productive tillers hill-1 during late kharif and normal rabi seasons. However, NLR 33358 was observed to be a good general combiner for grain yield, days to 50 per cent flowering, plant height and 1000 seed weight during normal rabi, while NLR 33359 was noticed to be a good general combiner for grain yield, productive tillers hill-1 and days to 50 per cent flowering during both rabi seasons studied in the present investigation.

2. Specific combining ability

The specific combining ability (sca) effect is an average performance of a cross expressed as a deviation from the population mean and is correlated with parental gca effects (Saidaih et al. 2010a). Specific combining ability effects of the 45 hybrids studied for salinity tolerant traits, and grain yield in different seasons are presented in Table 3.

3.2.1 Days to 50% flowering

Specific combining ability effects for days to 50% flowering in normal kharif, varied from -9.39 (NLR3041 X BPT2231) to 6.03 (NLR33057 X BPT2231). Significant negative sca effects desirable for the trait were recorded by seven cross combinations and hence, were identified as good specific combiners for days to 50% flowering during the season. Specific combining ability effects for days to 50% flowering in late kharif, varied from -8.35 (NLR33057 X NLR33671) to 6.06 (NLR33359 X NLR3041). Six hybrids had recorded significant and negative sca effects for the character and hence were recognized as good specific combiners during late kharif season.

Estimates of sca effects in normal rabi, ranged from -6.99 (NLR33359 X NLR40024) to 5.23 (NLR33359 X NLR3041). Significant and negative sca effects were recorded by seven hybrids for the character and hence were recognized as good specific combiners during normal rabi season. During late rabi, eight hybrids were recorded significant and negative sca effects for the character and hence were recognized as good specific combiners during late rabi season.

3.2.2 Plant height

Range of sca effects for plant height in normal kharif, varied from -19.42 (NLR33057 X NLR33671) to 17.09 (NLR40024 X MTU1001). Significant negative sca effects desirable for the trait were recorded by eight cross combinations and hence, were identified as good specific combiners for plant height during the season. Specific combining ability effects for plant height in late kharif, varied from -17.65 (NLR33057 X NLR33359) to 22.55 (MTU1061 X MTU1001). Eighteen cross combinations had recorded significant and negative sca effects for the character and hence were recognized as good specific combiners during late kharif season.

Estimates of sca effects in normal rabi, ranged from -7.99 (NLR40024 X BPT2231) to 11.91 (NLR33358 X MTU1061). However, the sca effects were significant and negative for twelve hybrids for the character and hence were recognized as good specific combiners during normal rabi season.

During late rabi, the sca effects were noticed to range from -10.28 (NLR33671 X PUSA1121) to 11.25 (NLR33358

X MTU1061). Seven cross combinations were recorded significant and negative sca effects for the character and hence was recognized as good specific combiners during late rabi season. The significant sca effects were also reported by Rahimi et al. (2010).

3.2.3 No. of productive tillers hill-1

During normal kharif, the sca effects were noticed to range from -1.29 (NLR33358 X PUSA1121) to 2.00 (NLR33359 X MTU 1001). Fourteen hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for productive tillers hill-1 during the season. Specific combining ability effects for productive tillers hill-1 in late kharif, varied from -2.75 (NLR33359 X NLR40024) to 2.85 (NLR40024 X MTU1001). Eleven hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for productive tillers hill-1 during the season. Estimates of sca effects in normal rabi, ranged from -1.75 (NLR3041 X PUSA1121) to 2.74 (NLR40024 X MTU1001). Nine hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for productive tillers per hill during the season. During late rabi, the sca effects were noticed to range from -2.43 (NLR33358 X NLR33359) to 3.00 (NLR40024 X MTU1001). Six hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for productive tillers hill-1 during the season. The significant sca effects were also reported by Rahimi et al. (2010).

3.2.4 Spikelet fertility

For spikelet fertility percentage in normal kharif, the sca effects were noticed to range from -9.43 (NLR33057 X NLR40024) to 7.77 (NLR40024 X MTU1001). Three hybrids (NLR 33057 X MTU1061, NLR33359 X MTU1001 and NLR40024 X MTU1001) had recorded positive and significant effects and hence, were identified as good specific combiners for spikelet fertility percentage during the season. Specific combining ability effects for spikelet fertility percentage in late kharif, varied from -16.47 (NLR33057 X NLR33671) to 13.04 (NLR33057 X NLR3041). Six hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for spikelet fertility percentage during the season. Estimates of sca effects in normal rabi, ranged from -15.95 (NLR33359 X NLR40024) to 9.00 (NLR33359 X MTU1001). Six hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for spikelet fertility percentage during the season. During late rabi, the sca effects were noticed to range from -18.92 (MTU1001 X PUSA1121) to 13.13 (NLR33358 X MTU1001). Six hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for spikelet fertility percentage during the season. 3.2.5 1000 seed weight

1000 seed weight sca effects in normal kharif, varied from -3.11 (NLR33057 X NLR3041) to 2.85 (NLR3041 X BPT2231). Three hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for 1000 seed weight during the season.

Specific combining ability effects for 1000 seed weight in late kharif, varied from -3.46 (NLR33358 X NLR40024) to 1.71 (NLR33671 X MTU1061). One hybrid (NLR33671 X MTU1061) was recorded positive and significant effects and hence, was identified as good specific combiners for 1000 seed weight during the season.Estimates of sca effects in normal rabi, ranged from -4.12 (MTU1061 X BPT2231) to 4.54 (NLR3041 X BPT2231). Twenty one hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for 1000 seed weight during the season.

During late rabi, the sca effects were noticed to range from -2.93 (NLR40024 X BPT2231) to 2.88 (MTU1061 X MTU1001). Ten hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for 1000 seed weight during the season. The significant sca effects were also reported by Rahimi et al. (2010).

3.2.6 Grain yield plant-1

During normal kharif, the sca effects were noticed to range from -2.31 (MTU1001 X PUSA1121) to 5.09 (MTU1001 X BPT2231). Twelve hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for grain yield plant-1 during the season. Specific combining ability effects for grain yield plant-1 in late kharif, varied from -4.19 (NLR33359 X NLR40024) to 8.95 (NLR33359 X MTU1001). Eight hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for grain yield plant-1 during the season.

Estimates of sca effects in normal rabi, ranged from -5.53 (MTU1001 X PUSA1121) to 13.93 (NLR33359 X MTU1001). Fifteen hybrids had recorded positive and significant effects and hence, were identified as good specific combiners for grain yield plant-1 during the season. During late rabi, the sca effects were noticed to range from -5.76 (MTU1001 X PUSA1121) to 15.99 (NLR33359 X MTU1001). Eight hybrids had recorded positive and significant effects and hence, were identified as good specific

combiners for grain yield plant-1 during the season. Rahimi et al. (2010) reported significant and positive sca effects for grain yield plant.-1 A high sca effect for grain yield per plant was reported by Pradhan and Singh (2008).

In general, the hybrids, NLR 33359 X MTU 1001, NLR 40024 X MTU 1061 and NLR 40024 X MTU 1001 were noticed to be good specific combiners across all the seasons studied with regards to grain yield and yield component traits, indicating their potential as promising hybrids for saline conditions. The hybrids, NLR 33057 X NLR 3041, NLR 33057 X MTU 1061 and MTU 1001 X BPT 2231 were also noticed to be good specific combiners for normal and late kharif seasons studied with regards to grain yield and few other traits studied. The hybrid, NLR 40024 X PUSA 1121 was noticed to be a good specific combiner for normal kharif and rabi in addition to late rabi with regards to grain yield, productive tillers hill-1 and plant height Further, the hybrids NLR 33358 X MTU 1061, NLR 33358 X MTU 1001 and NLR 33359 X MTU 1061 were noticed to be good specific combiners for both normal and late rabi with regards to grain yield.

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Table 1. Mean squares due to gca, sca and their interactions with seasons for yield components and grain yield in rice under saline conditions.

Source of variation	df	Days to 50% flowering				Plant height				No. of productive tillers hill^{-1}			
		Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*
gca	9	354.84**	261.52**	296.34**	275.98**	102.1**	323.79**	390.19**	324.3**	12.76**	4.1**	6.46**	5.46**
sca	45	21.86**	22.63**	8.93**	13.19**	120.53**	127.11**	62.71**	54.71**	0.86**	1.96**	1.42**	1.64**
Error	108	6.98	4.38	3.24	3.71	11.81	10.42	6.81	10.67	0.09	0.29	0.29	0.38
σ^2gca		28.99	21.43	24.43	22.69	7.52	26.11	31.95	26.14	1.06	0.32	0.51	0.42
σ^2sca		14.88	18.25	5.69	9.47	108.73	116.69	55.9	44.04	0.8	1.67	1.13	1.25
σ^2gca /σ^2sca		1.94	1.17	4.3	2.39	0.07	0.22	0.57	0.59	1.38	0.19	0.46	0.34

*Significant at 5 per cent level **Significant at 1 per cent level

Table 1. Contd….

Source of variation	df	Spikelet fertility				1000 seed weight				Grain yield plant^{-1}			
		Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*
gca	9	280.17**	221.2**	140.04**	146.18**	22.92**	20.1**	22.49**	36.06**	61.38**	12.81**	47.13**	55.74**
sca	45	45.42**	38.24**	48.01**	54.55**	3.31**	2.67**	3.81**	1.75**	7.08**	6.97**	21.21**	18.23**
Error	108	12.2	11.72	12.69	12.27	1.13	1.003	0.03	0.03	0.26	0.63	0.45	0.79
σ^2gca		22.33	17.46	10.61	11.16	1.82	1.59	1.87	3.02	5.09	1.01	3.89	4.58
σ^2sca		33.22	26.51	35.32	42.28	2.18	1.67	3.78	1.72	6.82	6.34	20.76	17.45
σ^2gca /σ^2sca		0.67	0.66	0.31	0.26	0.83	0.95	0.49	1.74	0.75	0.16	0.19	0.26

*Significant at 5 per cent level **Significant at 1 per cent level

Table 2. General combining ability effects of the parents for yield components and grain yield in different seasons under saline conditions.

Parent	Days to 50 per cent flowering				Plant height				No. of productive Tillers hill^{-1}			
	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*
NLR33057	-2.97**	-3.04**	-0.92	-1.20*	-0.71	3.16**	0.12	0.31	-0.82**	-0.04	-0.47**	-0.64**
NLR33358	-7.89**	-6.76**	-3.42**	-2.87**	-0.64	0.85	-6.93**	-6.09**	-1.39**	-0.26	0.02	0.30
NLR33359	-4.14**	-4.48**	-4.78**	-4.39**	1.26	4.92**	-0.52	-0.62	-0.96**	-0.11	0.35*	0.44*
NLR40024	-4.89**	-3.98**	-5.47**	-4.48**	-1.65	-3.71**	-2.56**	-4.31**	-0.58**	0.43**	1.06**	0.81**
NLR3041	7.44**	4.38**	5.97**	5.66**	-2.86**	-5.43**	-2.87**	-2.81**	0.05	0.39**	-0.91**	-0.73**
NLR33671	0.11	0.35	-2.06**	-3.59**	-1.30	-10.13**	-1.04	-1.22	-0.20*	-0.84**	-0.93**	-0.66**
MTU1061	4.31**	5.74**	2.42**	2.47**	7.34**	3.88**	12.03**	11.33**	1.54**	0.64**	0.53**	0.45**
MTU1001	-0.17	0.43	-3.97**	-3.70**	-0.44	6.44**	7.70**	6.53**	1.59**	0.79**	0.98**	1.03**
PUSA1121	-0.72	0.10	2.89**	2.88**	-2.36*	-1.67	-4.82**	-2.52**	-0.09	-0.95**	-0.67**	-0.56**
BPT2231	8.92**	7.27**	9.33**	9.22**	1.35	1.68	-1.10	-0.60	0.88**	-0.05	0.05	-0.45**
SE (g_i) ±	0.72	0.57	0.49	0.53	0.94	0.88	0.72	0.90	0.09	0.15	0.15	0.17

*Significant at 5 per cent level **Significant at 1 per cent level

Table 2. Contd….

Parent	Spikelet fertility percentage				1000 Seed weight				Grain yield plant^{-1}			
	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*
NLR33057	-3.36**	3.12**	-2.45*	-0.97	0.49	0.45	1.23**	1.04**	-1.26**	-0.06	-1.65**	-1.80**
NLR33358	-4.95**	-4.37**	-0.50	1.13	-0.11	0.04	0.97**	1.00**	-2.24**	-0.09	0.41*	0.47
NLR33359	-2.39*	1.78	0.17	2.28*	-0.18	0.09	0.79**	0.65**	-1.03**	0.28	1.35**	1.60**
NLR40024	-2.93**	5.24**	1.53	1.95*	-0.52	-0.62*	-0.98**	-0.61**	-1.27**	0.94**	0.56**	0.42
NLR3041	-0.06	-1.57	-1.49	-2.96**	-1.64**	-1.07**	-3.16**	-3.72**	-0.57**	-0.06	-2.27**	-0.66**
NLR33671	-2.12*	-5.67**	0.16	-5.59**	-0.61*	-0.87**	0.73**	0.84**	-0.25	-1.53**	-0.39*	-2.17**
MTU1061	8.42**	3.43**	4.17**	4.13**	1.83**	1.53**	0.50**	1.11**	3.65**	0.57**	1.41**	1.37**
MTU1001	7.97**	5.61**	5.90**	3.85**	1.97**	2.17**	0.41**	1.42**	4.22**	1.89**	4.07**	4.55**
PUSA1121	-3.52**	-3.84**	-1.12	1.20	-2.29**	-2.28**	-1.18**	-2.43**	-2.12**	-1.48**	-1.29**	-2.46**
BPT2231	2.94**	-3.72**	-6.38**	-5.01**	1.06**	0.55*	0.69**	0.70**	0.87**	-0.46*	-2.19**	-1.34**
SE (g_i) ±	0.96	0.94	0.98	0.96	0.29	0.27	0.05	0.05	0.14	0.22	0.18	0.24

*Significant at 5 per cent level **Significant at 1 per cent level

Table 3. Specific combining ability effects of hybrids for yield components and grain yield in different seasons under saline conditions.

Hybrids	Days to 50 per cent flowering				Plant height				No. of productive Tillers hill^{-1}			
	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*
NLR33057 X NLR33358	0.83	1.76	-1.24	-1.79	-1.30	-8.39**	7.05**	6.76*	-0.36	0.36	0.43	0.08
NLR33057 X NLR33359	-4.92*	-1.19	2.45	-1.93	-0.29	-17.65**	-0.26	0.71	-0.09	-1.63**	1.99**	1.66**
NLR33057 X NLR40024	-5.17*	-3.02	0.81	-2.51	11.06**	-4.87	1.02	3.52	-0.67*	-0.52	-1.02*	-0.78
NLR33057 X NLR3041	4.50	2.62	-1.30	-1.65	7.40*	17.03**	-0.85	-0.32	1.00**	2.31**	-0.24	-0.32
NLR33057 X NLR33671	-9.17**	-8.35**	-3.60*	-0.40	-19.42**	-8.36**	-4.03	-3.25	0.15	-0.36	-0.43	-0.58
NLR33057 X MTU1061	5.64*	-0.74	-2.08	-0.45	5.05	7.70*	4.61	3.33	1.41**	1.63**	1.22*	1.11
NLR33057 X MTU1001	0.11	0.56	-2.35	-0.95	8.01*	3.92	4.41	2.55	0.46	0.31	-0.13	-1.99**
NLR33057 X PUSA1121	-0.34	-1.10	-1.55	-0.87	4.39	-9.75**	-1.79	-4.69	-0.76*	-0.04	-0.39	1.06
NLR33057 X BPT2231	6.03*	0.73	1.01	0.80	-15.63**	9.16**	2.64	2.43	0.77**	0.95	0.33	-0.06
NLR33358 X NLR33359	-1.00	-5.80**	-3.38*	-1.26	-1.29	10.08**	-7.63**	-7.24*	-0.43	-0.56	-1.37**	-2.43**
NLR33358 X NLR40024	0.75	-3.30	-1.02	-2.84	-3.30	-4.63	-5.19*	-3.79	-0.10	-1.60**	1.19*	0.71
NLR33358 X NLR3041	2.41	3.34	3.20	1.02	16.57**	19.31**	-5.86*	-5.80	0.01	2.33**	-0.70	-0.54
NLR33358 X NLR33671	-3.25	-2.63	-1.77	-2.73	4.07	-6.09*	-6.34*	-7.10*	1.32**	0.17	0.15	1.36*
NLR33358 X MTU1061	2.55	4.98*	0.42	-0.79	7.08*	8.70**	11.91**	11.25**	-0.33	-0.51	0.89	2.26**
NLR33358 X MTU1001	-3.97	3.29	-4.19*	-2.62	6.17	-13.37**	7.54**	10.66**	-0.04	-0.96	1.68**	0.34
NLR33358 X PUSA1121	0.58	1.62	1.95	1.80	-3.46	-6.03*	2.15	0.40	-1.29**	0.32	-0.58	0.37
NLR33358 X BPT2231	4.94*	0.45	1.51	4.13*	-15.28**	-7.73*	-6.79**	-4.76	0.64*	0.58	0.30	-1.28*
NLR33359 X NLR40024	-3.00	3.76	-6.99**	-6.32**	-4.15	-10.87**	4.30	2.59	-1.23**	-2.75**	-0.84	-0.96
NLR33359 X NLR3041	-0.34	6.06**	5.23**	3.55	5.12	2.09	1.72	3.86	0.63*	0.48	-0.70	-0.50
NLR33359 X NLR33671	-7.00**	-6.91**	-1.74	-3.20	4.25	-11.87**	-1.21	-1.82	0.19	0.12	-0.05	0.32
NLR33359 X MTU1061	1.80	2.70	2.79	2.74	4.20	5.56	4.76	2.64	-0.66*	-0.06	0.09	-0.24
NLR33359 X MTU1001	3.28	1.01	-1.83	-4.09*	-13.50**	14.23**	2.91	4.19	2.00**	1.65**	2.34**	2.51**
NLR33359 X PUSA1121	5.83*	-1.66	2.31	4.32*	-6.86*	13.62**	-1.20	1.92	1.38**	2.23**	1.35**	0.77

*Significant at 5 per cent level **Significant at 1 per cent level

Table 3. Contd….

Hybrids	Days to 50 per cent flowering				Plant height				No. of productive Tillers hill^{-1}			
	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*
NLR33359 X BPT2231	2.19	4.17*	1.87	4.32*	7.14*	-15.22**	1.67	-4.56	0.41	0.52	-0.03	0.12
NLR40024 X NLR3041	2.41	4.56*	4.92**	2.63	7.34*	3.31	-7.13**	-4.55	0.46	1.65**	2.13**	1.74**
NLR40024 X NLR33671	-7.25**	-6.41**	-2.05	-2.79	1.02	-3.35	-7.82**	-6.14*	0.11	0.38	0.71	-0.40
NLR40024 X MTU1061	0.55	2.20	2.48	3.82*	0.72	-5.93	9.20**	9.40**	-0.83**	0.10	-0.52	-0.52
NLR40024 X MTU1001	-0.97	-3.49	-1.80	-3.68*	17.09**	17.91**	6.06*	8.97**	1.22**	2.85**	2.74**	3.00**
NLR40024 X PUSA1121	2.58	0.84	2.01	4.41*	-16.68**	-11.29**	-2.75*	-2.36*	0.80**	1.19*	0.08*	-0.05*
NLR40024 X BPT2231	1.94	1.67	1.56	5.07**	-0.44	3.24	-7.99**	-6.68*	0.13	0.39	-1.07*	0.11
NLR3041 X NLR33671	2.75	2.23	0.51	1.74	8.79**	-1.52**	-2.61	-1.03	-0.02	-0.39	0.12	-0.40
NLR3041 X MTU1061	-2.78	-1.16	-2.96	-2.32	6.25	-13.86**	11.26**	6.66*	1.03**	0.27	0.23	-0.15
NLR3041 X MTU1001	-3.31	0.15	-0.58	5.52**	-4.67	-6.21*	9.23**	5.55	0.69*	0.98	0.31	0.91
NLR3041 X PUSA1121	-1.75	2.48	-5.44**	-3.73*	16.78**	-9.93**	-1.38	0.31	-0.83**	-2.27**	-1.75**	-1.93**
NLR3041 X BPT2231	-9.39**	1.31	-3.88*	-9.07**	-15.67**	-2.71	-1.94	-5.46	-0.20	-0.58	0.67	-0.05
NLR33671 X MTU1061	2.55	-5.13*	-0.94	-0.07	10.64**	3.56	-0.42	6.49*	0.89**	1.17*	0.01	-0.31
NLR33671 X MTU1001	-4.97*	-1.83	-1.55	-4.90**	-2.42	-5.51	8.59	2.02	0.34	0.12	-0.47	1.12
NLR33671 X PUSA1121	-2.42	-2.49	-0.41	2.52	4.19	4.41	-7.11**	-10.28**	-0.68*	-0.44	-1.57**	-1.71**
NLR33671 X BPT2231	-2.06	-3.66	1.15	3.18	14.77**	1.98	-7.26**	-6.58*	0.25	1.06*	1.15*	0.23
MTU1061 X MTU1001	1.83	-3.21	1.98	1.05	14.58**	22.55**	2.89	3.30	0.60*	1.04*	0.30	0.99
MTU1061 X PUSA1121	1.39	-1.88	-3.88*	-6.54**	-3.17	-1.26	0.95	-0.56	0.38	0.88	0.41	0.13
MTU1061 X BPT2231	-4.25	-4.05*	-2.33	-1.20	-4.25	-16.12**	1.37	3.39	-0.09	0.58	-0.77	-0.52
MTU1001 X PUSA1121	-1.14	-1.58	2.51	2.63	-12.45**	-4.42	-3.43	1.82	-0.37	-0.77	-0.90	-2.16**
MTU1001 X BPT2231	-0.78	-3.74	3.06	1.30	3.15	-5.88	0.02	-3.66	-0.24	0.06	-0.75	-0.56
PUSA1121 X BPT2231	1.78	-2.41	-2.80	-5.29**	8.55**	-6.06*	-6.96**	2.13	-0.06	-0.83	0.49	0.87
SE (Sij) ±	2.43	1.93	1.66	1.78	3.17	2.97	2.40	3.01	0.29	0.49	0.50	0.57

*Significant at 5 per cent level **Significant at 1 per cent level

Table 3. Contd.…

Hybrids	Spikelet fertility percentage				1000 Seed weight				Grain yield plant^{-1}			
	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*
NLR33057 X NLR33358	-4.97	-5.43	3.96	3.39	1.64	1.40	0.33*	0.08	0.05	-0.15	-1.12	-0.09
NLR33057 X NLR33359	3.50	4.90	6.04	4.72	-2.58*	-2.24*	-0.07	0.05	-0.32	-1.81*	6.84**	-3.48**
NLR33057 X NLR40024	-9.43**	3.08	6.68*	-6.49	-0.29	-0.64	0.13	-0.20	-1.80**	-1.88*	-2.18**	-0.85
NLR33057 X NLR3041	-9.10**	13.04**	-6.93*	-9.01**	-3.11**	-3.22**	-1.73**	-1.12**	1.02*	5.52**	-0.94	0.32
NLR33057 X NLR33671	-1.02	-16.47**	-11.69**	-2.56	1.70	1.00	0.24	0.31	-1.21*	-1.51*	2.68**	0.25
NLR33057 X MTU1061	6.61*	-0.10	-8.22*	2.60	-1.27	-0.38	-0.38*	-0.89**	3.99**	1.99**	-1.53*	0.07
NLR33057 X MTU1001	2.87	-6.24	7.04*	-0.69	1.15	1.29	2.34**	0.83**	1.75**	-4.16**	-1.10	-0.04
NLR33057 X PUSA1121	-7.28*	9.59**	-1.31	10.38**	-0.77	0.07	-2.05	-0.50**	-0.82	0.03	-1.04	0.99
NLR33057 X BPT2231	-4.59	-3.07	-5.43	-1.42	0.98	0.47	0.32*	0.35*	-0.46	1.22	-0.61	1.16
NLR33358 X NLR33359	-5.34	-4.05	-7.17*	-2.32	-0.42	-0.90	0.36*	0.33*	0.07	1.22	-3.54**	-2.43**
NLR33358 X NLR40024	-4.36	-0.49	7.57*	4.27	-2.44*	-3.46**	-0.10	0.05	0.48	-0.86	-5.05**	-3.75**
NLR33358 X NLR3041	4.25	3.55	-11.28**	-9.62**	-2.81**	-1.35	-2.64**	-2.20**	0.49	2.92**	-2.41**	-0.46
NLR33358 X NLR33671	-7.96*	4.01	4.50	-9.01**	-0.52	-0.44	0.37*	0.15	-0.22	0.03	8.01**	-2.17*
NLR33358 X MTU1061	3.28	-0.46	5.76	2.82	-0.43	0.65	0.70**	-0.04	0.77	-0.07	3.11**	4.44**
NLR33358 X MTU1001	-3.38	-4.91	8.65*	13.13**	0.38	0.86	1.72**	0.61**	-1.69**	-1.79*	11.64**	12.34**
NLR33358 X PUSA1121	-5.91	-1.22	-10.62**	6.17	0.56	0.55	-1.71**	-0.49**	0.74	-0.92	1.24	-1.90*
NLR33358 X BPT2231	1.90	1.40	-5.94	-8.30*	0.27	-0.16	0.33*	0.32*	-0.85	0.18	-2.76**	0.92
NLR33359 X NLR40024	-8.37*	1.71	-15.95**	0.99	0.04*	-0.26	0.33*	0.07	-1.22*	-4.19**	4.23**	-0.69
NLR33359 X NLR3041	-6.09	-6.92*	4.52	-12.50**	-2.35*	-1.85	-1.64**	-1.09**	-0.75	-0.51	-3.31**	6.53**
NLR33359 X NLR33671	-6.24	-6.60*	4.39	-9.24**	1.82	1.18	-0.31	-0.45**	-2.03**	-1.10	-5.35**	-3.05**
NLR33359 X MTU1061	0.98	2.68	5.15	5.92	0.56	0.48	0.82**	-0.03	2.16**	-1.01	1.96**	3.11**
NLR33359 X MTU1001	6.70*	9.57**	9.00**	12.77**	-0.30	1.17	1.41**	-0.02	4.50**	8.95**	13.93**	15.99**
NLR33359 X PUSA1121	2.17	-0.62	1.94	5.94	-0.66	-0.14	-2.29**	-1.10**	0.63	1.60*	-0.01	-1.33

*Significant at 5 per cent level **Significant at 1 per cent level

Table 3. Contd…

Hybrids	Spikelet fertility percentage				1000 Seed weight				Grain yield plant^{-1}			
	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*	Normal *kharif*	Late *kharif*	Normal *rabi*	Late *rabi*
NLR33359 X BPT2231	0.10	0.27	-7.93*	1.01	0.02	-0.34	-0.31*	-0.28	-1.76**	-0.50	-1.89**	-3.80**
NLR40024 X NLR3041	0.08	5.20	-1.28	12.59**	-2.47*	-2.14*	0.01	-0.20	-0.77	0.85	-2.53**	-0.17
NLR40024 X NLR33671	-4.23	6.80*	2.49	-11.62**	0.79	0.96	0.39*	-0.20	-1.20*	-0.86	5.15**	1.47
NLR40024 X MTU1061	1.11	2.10	-0.52	0.44	0.39	1.15	1.25**	0.47**	1.30**	2.00**	1.55*	1.80*
NLR40024 X MTU1001	7.77*	3.96	3.70	1.36	1.66	1.37	-2.48**	-0.52**	4.23**	7.71**	4.09**	3.74**
NLR40024 X PUSA1121	1.54	-6.69*	4.14	-1.93	-0.19	-0.01	-0.64**	0.01	1.05*	-0.15	2.05**	3.81**
NLR40024 X BPT2231	-0.73	-5.17	-7.57*	-2.61	0.27	0.48	-3.15**	-2.93**	-0.86	-0.56	-1.11	-2.70**
NLR3041 X NLR33671	1.05	-3.28	2.53	12.16**	-2.02*	-1.81	-1.80**	-0.62**	-0.99*	-0.90	3.33**	0.40
NLR3041 X MTU1061	5.14	-1.47	3.82	-6.02	1.44	1.44	-1.14**	-2.04**	3.70**	-1.40	-0.72	-1.48
NLR3041 X MTU1001	4.88	4.27	4.78	6.12	-0.03	1.36	-2.32**	-1.66**	1.65**	-0.32	0.72	-2.21**
NLR3041 X PUSA1121	-0.33	0.40	4.21	4.58	-0.36	-0.39	0.78**	1.11**	0.19	-3.01**	4.33**	-0.14
NLR3041 X BPT2231	-5.76	-9.42**	-2.66	-3.50	2.85**	1.14	4.54**	-0.79**	-1.53**	-1.76*	0.58	0.59
NLR33671 X MTU1061	1.48	-2.70	-0.57	-0.99	2.17*	1.71*	1.04**	0.11	0.51	0.33	-3.50**	-0.49
NLR33671 X MTU1001	5.79	0.43	-1.33	-1.56	0.44	0.46	-4.11**	-0.18	0.70	-1.55*	-3.73**	-2.77**
NLR33671 X PUSA1121	-5.08	0.06	-9.62**	-2.56	0.03	0.43	2.60**	-1.37**	-0.64	-1.27	1.03	-0.27
NLR33671 X BPT2231	-7.34*	6.80*	7.42*	6.90*	1.14	0.97	0.47**	0.49**	-0.73	1.23	-1.70**	1.05
MTU1061 X MTU1001	-0.32	5.11	-5.99	2.86	1.97	1.54	-2.85**	2.88**	3.96**	-0.49	0.54	-1.34
MTU1061 X PUSA1121	-7.44*	-1.35	0.80	-3.25	1.35	-1.78	2.87**	-0.59**	-0.84	1.14	0.43	0.86
MTU1061 X BPT2231	0.66	-2.89	1.97	-0.26	-1.45	-1.88*	-4.12**	0.36*	0.76	-0.50	5.41**	-1.37
MTU1001 X PUSA1121	-3.56	-12.68**	-10.13**	-18.92**	-2.98**	-2.92**	1.48**	-2.01**	-2.31**	-2.89**	-5.53**	-5.76**
MTU1001 X BPT2231	4.42	10.63**	4.51	-2.51	-1.54	-2.28*	1.10**	-0.09	5.09**	1.81*	-2.36**	0.70
PUSA1121 X BPT2231	-2.36	-1.65	2.00	-3.12	-0.93	0.46	-1.54**	-0.37*	0.33	-0.18	0.43	0.57
SE (Sij) ±	3.22	3.16	3.28	3.23	0.98	0.92	0.15	0.16	0.47	0.73	0.62	0.82

*Significant at 5 per cent level **Significant at 1 per cent level