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Studies on Combining Ability of Salinity Tolerant Restorer Lines in Rice

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ABSTRACT

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Combining ability analysis of 14 salinity tolerant restorer lines was undertaken for grain yield and yield components in rice. Non-additive gene action was noticed to be pre-ponderant for grain yield per plant and majority of the yield traits studied. A perusal of *gca* effects revealed MTU 1153, MCM 225, MTU 1156, MCM 48, IR 64 and MTU 1210 were noticed to be good combiners for grain yield per plant, indicating their suitability in breeding programmes for development of high yielding salinity tolerance hybrids. Among the hybrids 13 crosses had exhibited significant and desirable *sca* effects for grain yield per plant and are identified as potential salinity tolerant hybrids for commercial exploitation.

Introduction

Rice is an important staple food for people in Asia, Latin America, parts of Africa and the Middle East. Rice production employs one billion people and is essential for the economic development of rural areas in India, Bangladesh and Southeast Asia. In India, rice is cultivated in an area of 43.39 million hectares with a production of 104.32 million tonnes and an average productivity of 2404 kg/ha. Andhra Pradesh is one of the leaders in rice production with an area, production and productivity of 2.16 million hectares, 7.49 million tonnes and 3466 kg/ha., respectively (Directorate of Economics and Statistics, 2015-16).

Significant improvement in rice production and productivity was achieved through green revolution but the plateau in yield levels coupled with biotic and abiotic stresses are limiting the efforts for increasing production to meet the demands of the ever growing population especially in the developing and under developed countries.

Abiotic stresses alone contribute to 50 per cent of the total yield losses. Salinity (both inland and coastal salinity) is the second most important abiotic stress after drought, which affects the rice production. Nearly 20 per cent of the world's cultivated area (800 million hectares) and nearly half of the world's irrigated lands are affected by salinity (Maser

et al., 2002). In Andhra Pradesh, 2.74 lakh hectares of rice area is affected by salinity (NRSC, 2010).

Out of the various approaches contemplated to enhance rice productivity, hybrid rice technology has been considered to be a more practically feasible option, particularly under stress environments. The success of hybrid rice programme for salinity tolerance depends on the availability of male sterile and salinity tolerant restorer lines with good combining ability. The present investigation was undertaken in this context to study the combining ability of salinity tolerant restorer lines for yield and yield components.

Materials and Methods

The experimental material comprised of three cytoplasmic male sterile lines namely, APMS 6A, APMS 9A, APMS 12A and 14 salinity tolerant restorer lines as testers, namely, MTU 1010, MTU 1153, MTU 1156, MTU 1121, MTU 1210, MTU 1229, MTU 1032, IR 64, IR 7693-2B-7, MCM 223, MTU 1031, MCM 48, MCM 225 and MTU 1213 obtained from Regional Agricultural Research Station (RARS), Maruteru and their 42 hybrids derived from the 3 x 14 Line x Tester mating design. The hybrids and parents were evaluated in a Randomized Block Design with three replications at RARS, Maruteru during *Rabi* 2016-17 for grain yield; yield component characters, namely, days to 50 per cent flowering, days to maturity, plant height, total tillers per plant, ear bearing tillers per plant, panicle length, filled grains per panicle, ill-filled grains per panicle, spikelet fertility percentage; and 100-seed weight. The sowings were undertaken in the nursery during the second fortnight of November and the transplanting of seedlings were affected 25 days after sowing depending on the growth of seedlings. Normal, healthy and vigorous seedlings of each genotype were transplanted

in a single row plot of 2.0 meter length, with a spacing of 20 x 15 cm and the crop was raised following recommended package of practices. Further, data was recorded on five randomly selected plants in each replication for the characters, namely, plant height, total tillers per plant, ear bearing tillers per plant, panicle length, filled grains per panicle, ill-filled grains per panicle and spikelet fertility percentage for all the genotypes. However, for days to 50 per cent flowering and days to maturity, the data was recorded on plot basis, while observations on 100-Seed weight were obtained from a random grain sample drawn from each genotype in each replication. The estimates of combining ability variances and effects were obtained using Line x Tester analysis detailed by Kempthorne (1957).

Results and Discussion

The results on analysis of variance are presented in Table 1. Significant mean sum of squares were noticed for parents, hybrids and parents vs. hybrids components of variation for all the characters studied, with the exception of total tillers per plant and ear bearing tillers per plant for parents; and ear bearing tillers per plant, filled grains per panicle and 100- seed weight for parents vs. hybrids component of variation. The results indicated the existence of significant differences among the parents and hybrids, in addition to heterosis for the characters with significant mean sum of squares for parents vs. hybrids.

Further, partitioning of the hybrids component of variation into lines, testers and line x testers also revealed significant mean squares for grain yield per plant, days to 50 per cent flowering, days to maturity, plant height, filled and ill-filled grains per panicle, spikelet fertility and 100-seed weight indicating the importance of both additive and non-additive gene actions. A perusal of the

results on *gca:sca* variance ratio indicated pre-ponderant non-additive gene action for grain yield per plant (Savita *et al.*, 2015); and majority of the yield components studied, namely, days to 50 per cent flowering (Sathya and Jebaraj, 2015), days to maturity (Upadhyay and Jaiswal, 2015), plant height (Sathya and Jebaraj, 2015), total tillers per plant (Jhansi and Satyanarayana, 2015), panicle length (Sathya and Jebaraj, 2015), filled grains per panicle (Upadhyay and Jaiswal, 2015), ill-filled grains per panicle, spikelet fertility (Senguttuvel, 2008) and 100 seed weight (Bineetha and Lal, 2015), similar to the reports of earlier workers. Non-additive gene action is desirable in the present context, as lines used in the present investigation are all cytoplasmic male sterile lines facilitating the exploitation of heterosis. However, ear bearing tillers per plant had recorded pre-ponderant additive gene action. Similar pre-ponderant additive gene action for ear bearing tillers per plant was reported earlier by Zaazaa and Anis (2014).

The results of general combining ability effects for grain yield and yield components for lines and testers are presented in Table 2. General combining ability effects for days to 50 per cent flowering ranged from -1.43 (APMS 6A) to 0.74 (APMS 9A) in lines and from -7.50 (MTU 1121) to 8.83 (MTU 1229) in the testers, while for days to maturity, it ranged from -1.90 (APMS 6A) to 0.98 (APMS 9A) in the lines and from -7.26 (MTU 1121) to 9.07 (MTU 1229) in the testers. General combining ability effects for plant height ranged from -1.78 (APMS 6A) to 1.56 (APMS 12A) in the lines and from -10.75 (IR 64) to 21.70 (MCM 225) in the testers, while for total tillers per plant, the effects ranged from -0.50 (APMS 9A) to 0.67 (APMS 6A) in the lines and from -0.94 (MCM 225) to 1.39 (MTU 1032) in the testers. However, for ear bearing tillers per plant, the effects ranged from -0.46 (APMS 9A) to 0.80 (APMS 6A) in

the lines and from -0.92 (MCM 225) to 1.52 (MTU 1032) in the testers.

The *gca* effects for panicle length ranged from -0.92 (APMS 9A) to 0.88 (APMS 12A) in the lines and from -1.97 (MTU 1121) to 1.66 (MTU 1031) in the testers. Further, the effects ranged from -18.43 (APMS 9A) to 13.67 (APMS 6A) in the lines and from -48.17 (IR 7693-2B-7) to 116.50 (MTU 1229) in the testers for filled grains per panicle, while for ill-filled grains per panicle, the effects ranged from -3.67 (APMS 9A) to 4.14 (APMS 12A) in the lines and from -24.92 (MCM 48) to 31.30 (MTU 1032) in the testers. For spikelet fertility per cent, the effects ranged from -0.76 (APMS 9A) to 0.89 (APMS 12A) in the lines and -12.88 (MTU 1032) to 10.16 (MCM 48) in the testers. The *gca* effects ranged from -0.11 (APMS 9A) to 0.09 (APMS 12A) in the lines and from -0.45 (MTU 1213) to 0.25 (IR 64) in the testers for 100 seed weight, while general combining ability effects for grain yield per plant ranged from -2.38 (APMS 9A) to 2.65 (APMS 12A) in the lines and from -6.18 (MTU 1031) to 6.66 (MTU 1153) in the testers. The good general combiners identified for the various traits studied are presented in Table 3. A perusal of the results on categorization of the lines and salinity tolerant testers studied based on *gca* effects are presented in Table 4. The results revealed APMS 12 A to be a good combiner for grain yield per plant, 100-seed weight, panicle length and filled grains per panicle and hence may be utilized in hybrid breeding programmes for development of high yielding hybrids with long panicles, greater number of filled grains and higher seed weight. Further, among the testers, MTU 1153, MTU 1156, MTU 1210, IR 64, MCM 48 and MCM 225 were observed to be good combiners for grain yield per plant and few yield component characters, indicating their importance in hybrid breeding programmes aimed at the development of high yielding salinity tolerant hybrids.

Table.1 Line × Tester analysis of variance for grain yield and yield component characters in rice

Source of variation	Degrees of freedom	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Total tiller per plant	Ear bearing tillers per plant	Panicle length (cm)	Filled grains per panicle	Ill- filled grains per panicle	Spikelet fertility (%)	100-Seed weight (g)	Grain yield per plant (g)
Replications	2	2.87	2.87	31.15	1.80	2.15	1.03	17.51	11.60	5.67	0.04	2.53
Parents	16	464.00**	467.71**	1783.74**	2.52	2.63	13.67**	30099.69**	1951.20**	950.76 **	0.46**	277.75**
Hybrids	41	141.06**	145.03**	434.66**	4.56**	4.11**	13.47**	13719.29**	2298.25**	220.70**	0.26**	192.10**
Lines	2	38.11**	38.11**	242.66**	8.78**	9.33**	4.38	434.33**	40.11 *	28.94**	1.27**	28.40**
Testers	13	549.24**	553.52**	2137.19**	1.44	1.78	16.02**	33388.48**	2225.58**	316.76**	0.31**	312.61**
Line × Tester	26	126.69**	122.08**	254.08**	4.24**	2.79**	14.20**	10913.52**	2136.58**	187.43**	0.22**	215.86**
Parents vs. Crosses	1	263.90**	304.26**	1198.50**	36.31**	1.88	87.26**	51.09	4165.50**	2075.65**	0.05	651.15**
Error	118	1.69	1.67	15.27	1.49	1.54	2.74	24.67	8.86	4.77**	0.02	2.74
σ²GCA		4.75	6.01	18.27	0.30	0.42	0.73	610.75	68.73	6.59	0.01	7.73
σ²SCA		41.66	40.13	79.60	0.91	0.41	3.82	3629.61	709.24	60.88	0.06	71.03
σ²GCA/σ²SCA		0.11	0.14	0.22	0.32	1.02	0.19	0.16	0.09	0.10	0.16	0.10

*,**Significant at 5 and 1 per cent levels, respectively

Table.2 General combining ability effects of male sterile lines and salinity tolerant restorer testers for grain yield and yield component characters in rice

Parents	Days to 50 per cent flowering	Days to maturity	Plant Height (cm)	Total tillers per plant	Ear bearing tillers per plant	Panicle Length (cm)	Filled grains per panicle	Ill -filled grains per panicle	Spikelet fertility (%)	100- seed Weight (g)	Grain yield per plant (g)
Lines											
APMS6A	-1.43**	-1.90**	-1.78**	0.67**	0.80**	0.04	13.67**	-0.48	-0.13	0.02	-0.27
APMS9A	0.74**	0.98**	0.22	-0.50**	-0.46*	-0.92**	-18.43**	-3.67**	-0.76	-0.11**	-2.38**
APMS12A	0.69**	0.93**	1.56*	-0.17	-0.34	0.88**	4.76**	4.14**	0.89	0.09**	2.65**
SE(gi)	0.20	0.19	0.60	1.18	0.19	0.25	0.76	0.45	0.33	0.01	0.25
SE(gi-gj)	0.28	0.28	0.85	0.26	0.27	0.36	1.08	0.64	0.47	0.02	0.36
Testers											
MTU 1010	2.39**	2.63**	-8.30**	-0.06	0.08	-1.30	28.61**	-0.25	0.46	-0.14**	-4.18**
MTU 1153	-5.83**	-5.60**	-3.08*	0.17	0.30	0.13	-25.39**	2.97**	-4.62	0.06	6.66**
MTU 1156	-6.50**	-6.26**	-5.30**	0.28	0.41	-0.54	-32.06**	-21.48**	5.76	0.04	4.10**
MTU 1121	-7.50**	-7.26**	-3.63**	0.17	0.41	-1.97**	-16.28**	-22.48**	5.73	0.03	-2.72**
MTU 1210	-1.50**	-4.60**	-0.97	0.39	0.52	0.14	58.94**	3.08**	2.17	-0.13**	2.35**
MTU 1229	8.83**	9.07**	5.59**	-0.94*	-0.81	-0.23	116.50**	9.63**	-0.30	-0.09*	-4.34**
MTU 1032	3.39**	3.63**	-7.52**	1.39**	1.52**	0.47	-46.50**	31.30**	-12.88	0.23**	-2.71**
IR64	-0.83	-0.60	-10.75**	0.06	0.19	-0.10	-38.94**	1.52	-3.77	0.25**	2.13**
IR7693-2B-7	-1.83**	-1.60**	-1.97	-0.61	-0.48	0.40	-48.17**	-17.59**	2.36	0.18**	-0.45
MCM 223	-0.61	-0.37	19.14**	-0.28	-0.14	0.26	21.61**	-7.70**	3.70	-0.15**	0.45
MTU 1031	3.06**	3.29**	0.03	0.28	0.41	1.66**	12.72**	30.41**	-7.41	0.03	-6.18**
MCM 48	1.17**	1.40**	2.14	-0.50	-0.70	0.34	-20.17**	-24.92**	10.16	0.03	1.52**
MCM 225	2.39**	2.63**	21.70**	-0.94*	-0.92*	1.64**	22.06**	2.30*	1.15	0.11**	5.11**
MTU 1213	3.39**	3.63**	-7.08**	0.61	-0.81	-0.91	-32.94**	13.19**	-2.51	-0.45**	-1.74**
SE(gi)	0.43	0.43	1.30	0.40	0.41	0.55	1.65	0.99	0.72	0.04	0.55
SE(gi-gj)	0.61	0.60	1.84	0.57	0.58	0.78	2.34	1.40	1.02	0.06	0.78

*,**Significant at 5 and 1 per cent levels, respectively

Table.3 Promising salinity tolerant general combiners identified for grain yield and yield component characters in rice

Character	Lines	Testers
Days to 50% flowering	APMS 6A	MTU 1121,MTU 1156,MTU 1153,IR 7693-2B-7,MTU 1210
Days to maturity	APMS 6A	MTU 1121,MTU 1156,MTU 1153,MTU 1210, IR 7693-2B-7
Plant height	APMS 6A	IR 64, MTU 1010, MTU 1032,MTU 1213,MTU 1156, MTU 1153
Total tillers per plant	APMS 6A	MTU 1032
Ear bearing tillers per plant	APMS 6A	MTU 1032
Panicle length	APMS 12A	MTU 1031,MCM-225
Filled grains per panicle	APMS 6A	MTU 1229,MTU 1210,MTU 1010,MCM 225,MCM 223, MTU 1031
Ill filled grains per panicle	APMS 9A	MCM-48,MTU 1121,MTU 1156,IR 7693-2B-7,MCM 223
Spikelet fertility (%)	-	-
100 seed weight	APMS 12A	IR64,MTU 1032,IR7693-2B-7,MCM 225
Grain yield per plant	APMS 12A	MTU 1153,MCM-225,MTU 1156,MCM 48,IR 64, MTU 1210

Table.4 Characterization of parents based on *gca* effects

Line / Tester	Days to 50 per cent flowering	Days to maturity	Plant Height (cm)	Total tillers per plant	Ear bearing tillers per plant	Panicle Length(cm)	Filled grains per panicle	Ill-filled grains per panicle	Spikelet fertility (%)	100- seed Weight (g)	Grain yield per plant (g)
Lines											
APMS6A	H	H	H	H	H	L	H	L	L	L	L
APMS9A	L	L	L	L	L	L	L	H	L	L	L
APMS12A	L	L	L	L	L	H	H	L	L	H	H
Testers											
MTU 1010	L	L	H	L	L	L	H	L	L	L	L
MTU 1153	H	H	H	L	L	L	L	L	L	L	H
MTU 1156	H	H	H	L	L	L	L	H	L	L	H
MTU 1121	H	H	H	L	L	L	L	H	L	L	L
MTU 1210	H	H	L	L	L	L	H	L	L	L	H
MTU 1229	L	L	L	L	L	L	H	L	L	L	L
MTU 1032	L	L	H	H	H	L	L	L	L	H	L
IR64	L	L	H	L	L	L	L	L	L	H	H
IR7693-2B-7	H	H	L	L	L	L	L	H	L	H	L
MCM 223	L	L	L	L	L	L	H	H	L	L	L
MTU 1031	L	L	L	L	L	H	H	L	L	L	L
MCM 48	L	L	L	L	L	L	L	H	L	L	H
MCM 225	L	L	L	L	L	H	H	L	L	H	H
MTU 1213	L	L	H	L	L	L	L	L	L	L	L

H – High- significant effect in desirable direction for *gca*),

L – Low - non-significant effect or significant in undesirable direction for *gca*)

Table.5 Specific combining ability effects of the hybrids for grain yield and yield component characters in rice

Cross	Days to 50 per cent flowering	Days to maturity	Plant Height (g)	Total tillers per plant	Ear bearing tillers per plant	Panicle Length (g)	Filled grains per panicle	Ill-filled grains per panicle	Spikelet fertility (%)	100- seed Weight (g)	Grain yield per plant (g)
APMS6A x MTU 1010	9.87**	10.35**	0.44	0.22	0.09	0.85	16.22**	-0.41	1.81	-0.42**	-6.93**
APMS6A x MTU 1153	-5.24**	-4.76**	3.22	0.00	-0.13	0.08	-37.44**	16.03**	-7.30	-0.22**	-7.10**
APMS6A x MTU 1156	-7.24**	-6.76**	4.44	0.22	0.09	0.75	3.56	23.81**	-8.22	-0.11	-8.55**
APMS6A x MTU 1121	-4.90**	-4.43**	2.11	0.00	-0.25	0.85	48.11**	1.48	2.32	0.02	1.25
APMS6A x MTU 1210	5.10**	-1.10	-6.55**	0.11	-0.02	1.08	15.56**	12.92**	-2.87	0.09	-0.90
APMS6A x MTU 1229	5.76**	6.24**	7.22**	0.78	0.64	0.11	-53.00**	6.03**	-0.84	-0.07	-9.00**
APMS6A x MTU 1032	-1.46	-0.98	-5.00*	0.44	0.31	-2.26*	-54.33**	-36.30**	5.38	0.09	-1.40
APMS6A x IR64	8.76**	9.24**	2.56	0.44	0.31	-1.02	8.11**	32.48**	-8.94	-0.31**	13.44**
APMS6A x IR7693-2B-7	-1.90*	-1.43	-12.56**	0.11	-0.02	-2.18*	-14.33**	-1.41	0.81	0.18*	9.01**
APMS6A x MCM 223	-1.13	-0.65	2.33	-1.22	-1.36	1.28	32.89**	17.03**	-3.68	0.28**	5.12**
APMS6A x MTU 1031	-2.13**	-1.65*	-16.89**	1.56*	1.42	-1.12	-35.22**	-21.08**	7.36	0.10	-4.91**
APMS6A x MCM 48	1.10	1.57*	19.67**	-0.33	-0.13	0.21	-33.00**	-3.41	-1.40	0.18*	3.04**
APMS6A x MCM 225	-0.79	-0.32	-0.89	1.11	1.09	1.24	30.44**	-2.97	1.44	-0.13	1.46
APMS6A x MTU 1213	-5.79**	-5.32**	-0.11	-3.44**	-2.02**	0.12	72.44**	-44.19**	14.13	0.33**	5.45**
APMS9A x MTU 1010	-5.63**	-5.87**	-2.22	1.06	1.02	1.80	8.65*	-9.56**	4.56	0.24**	14.51**
APMS9A x MTU 1153	-3.40**	-3.64**	-1.44	-0.17	-0.21	-0.63	16.32**	25.22**	-6.02	0.31**	-5.66**
APMS9A x MTU 1156	-2.07**	-2.31**	-4.89*	-0.28	-0.32	-1.96*	-31.35**	-7.00**	3.14	0.19*	-6.77**
APMS9A x MTU 1121	-2.40**	-2.64**	-1.22	-0.50	-0.65	-1.20	18.87**	4.67**	0.77	0.10	1.38
APMS9A x MTU 1210	-2.07**	1.02	0.78	-0.06	-0.10	2.36*	37.65**	26.44**	-5.12	0.20**	0.97
APMS9A x MTU 1229	1.60*	1.36	3.22	-0.06	-0.10	-1.94*	-99.57**	-2.11	-4.28	0.25**	8.01**
APMS9A x MTU 1032	-1.96*	-2.20**	-3.00	-0.72	-0.76	-0.97	-6.24*	-26.78**	5.34	0.00	6.38**
APMS9A x IR64	4.26**	4.02**	-3.44	0.61	0.57	-0.40	16.54**	-25.00**	11.78	-0.20**	-4.46**

Table.5 Contd...

Cross	Days to 50 per cent flowering	Days to maturity	Plant Height (cm)	Total tillers per plant	Ear bearing tillers per plant	Panicle Length (cm)	Filled grains per panicle	Ill-filled grains per panicle	Spikelet fertility (%)	100- seed Weight (g)	Grain yield per plant (g)
APMS9A x IR7693-2B-7	-2.40**	-2.64**	14.78**	0.28	0.24	2.44*	24.76**	-3.22	4.63	0.01	-5.55**
APMS9A x MCM 223	2.37**	2.13**	-0.67	-0.06	-0.10	-3.43**	-63.02**	-21.44**	6.65	-0.45**	-8.32**
APMS9A x MTU 1031	-0.96	-1.20	-2.56	-0.61	-0.65	0.52	11.21**	13.78**	-4.21	-0.16*	-3.49**
APMS9A x MCM 48	5.26**	5.02**	-3.67	-0.83	-0.54	2.10	99.43**	7.11**	-1.10	-0.26**	2.50*
APMS9A x MCM 225	4.04**	3.80**	5.11*	-0.06	-0.32	-1.30	-19.13**	-2.78	-1.37	0.06	0.34
APMS9A x MTU 1213	3.37**	3.13**	-0.78	1.39	1.90**	2.61**	-14.13**	20.67**	-14.77	-0.31**	0.17
APMS12A x MTU 1010	-4.25**	-4.48**	1.78	-1.28	-1.10	-2.66**	-24.87**	9.97**	-6.37	0.17*	-7.58**
APMS12A x MTU 1153	8.64**	8.40**	-1.78	0.17	0.34	0.54	21.13**	-41.25**	13.32	-0.09	12.76**
APMS12A x MTU 1156	9.31**	9.07**	0.44	0.06	0.23	1.21	27.79**	-16.81**	5.08	-0.08	15.31**
APMS12A x MTU 1121	7.31**	7.07**	-0.89	0.50	0.90	0.34	-66.98**	-6.14**	-3.10	-0.12	-2.64**
APMS12A x MTU 1210	-3.02**	0.07	5.77*	-0.06	0.12	-3.43**	-53.21**	-39.37**	7.99	-0.29**	-0.07
APMS12A x MTU 1229	-7.36**	-7.60**	-10.44**	-0.72	-0.55	1.82	152.57**	-3.92*	5.12	-0.18*	0.99
APMS12A x MTU 1032	3.42**	3.18**	8.00**	0.28	0.45	3.23**	60.57**	63.08**	-10.72	-0.09	-4.98**
APMS12A x IR64	-13.02**	-13.26**	0.89	-1.06	-0.88	1.42	-24.65**	-7.48**	-2.84	0.51**	-8.98**
APMS12A x IR7693-2B-7	4.31**	4.07**	-2.22	-0.39	-0.21	-0.25	-10.43**	4.63**	-5.44	-0.19*	-3.46**
APMS12A x MCM 223	-1.25	-1.48*	-1.67	1.28	1.45	2.14*	30.13**	4.41*	-2.96	0.17*	3.20**
APMS12A x MTU 1031	3.09**	2.85**	19.44**	-0.94	-0.77	0.59	24.02**	7.30**	-3.15	0.06	8.40**
APMS12A x MCM 48	-6.36**	-6.60**	-16.00**	1.17	0.67	-2.30*	-66.43**	-3.70*	2.50	0.08	-5.54**
APMS12A x MCM 225	-3.25**	-3.48**	-4.22	-1.06	-0.77	0.06	-11.32**	5.75**	-0.07	0.07	-1.80
APMS12A x MTU 1213	2.42**	2.18**	0.89	2.06**	0.12	-2.73**	-58.32**	23.52**	0.64	-0.02	-5.62**
SE(sij)	0.75	0.74	2.25	0.70	0.71	0.95	2.86	1.71	1.26	0.07	0.95
SE(sij-skl)	1.06	1.05	3.19	0.99	1.01	1.35	4.05	2.43	1.78	0.10	1.35

*,**Significant at 5 and 1 per cent levels, respectively

Results of specific combining ability effects of the 42 hybrids derived from the line x tester mating of the three male sterile lines with the 14 salinity tolerant restorers and testers for yield and yield components revealed significant and desirable *sca* effects for several hybrids studied in the present investigation (Table 5). However, none of the hybrids studied had exhibited consistently high *sca* effects for all the characters studied and the best cross combination was also observed to vary from character to character. The results are in conformity with the reports of Prasad *et al.*, (2018).

Specific combining ability effects for days to 50 per cent flowering ranged from -13.02 (APMS 12A x IR 64) to 9.87 (APMS 6A x MTU 1010). Further, significant and negative *sca* effects, desirable for days to 50 per cent flowering were observed for 19 hybrids. The *sca* effects for days to maturity ranged for -13.26 (APMS 12A x IR64) to 10.35 (APMS 6A x MTU 1010). 17 hybrids had recorded significant and negative *sca* effects for the trait and hence were identified as good specific combiners for the trait.

Specific combining ability effects for plant height ranged from -16.89 (APMS 6A x MTU 1031) to 19.67 (APMS 6A x MCM 48). Significant and positive effects for the trait were observed in seven hybrids. For total tillers per plant, the effects ranged from -3.44 (APMS 6A x MTU 1213) to 2.06 (APMS 12A x MTU 1213). Significant and positive effects for the trait were observed in the hybrids, namely, APMS 6A x MTU 1031 and APMS 12A x MTU 1213. Further, specific combining ability effects for ear bearing tillers per plant ranged from -2.02 (APMS 6A x MTU 1213) to 1.90 (APMS 9A x MTU 1213). Significant and positive *sca* effects were observed for only one hybrid, namely, APMS 9A x MTU 1213.

For panicle length, the *sca* effects ranged from -3.43 (APMS 9A x MCM 223, APMS 12A x MTU 1210) to 3.23 (APMS 12A x MTU 1032). Further, significant and positive *sca* effects were observed for five hybrids. Specific combining ability effects for filled grains per panicle ranged from -99.57 (APMS 9A x MTU 1229) to 152.51 (APMS 12A x MTU 1229). Further, 21 hybrids had recorded significant and positive *sca* effects for the character. However, for ill-filled grains per panicle, the *sca* effects ranged from -44.19 (APMS 6A x MTU 1213) to 63.08 (APMS 12A x MTU 1032). Further, significant and negative *sca* effects, desirable for the trait were observed for 15 hybrids. Specific combining ability effects for spikelet fertility per cent ranged from -14.77 (APMS 9A x MTU 1213) to 13.32 (APMS 12A x MTU 1153). None of the hybrids studied had exhibited significant and positive effects for the trait

Specific combining ability effects for 100 seed weight ranged from -0.45 (APMS 9A x MCM 223) to 0.51 (APMS 12A x IR 64). Further, significant and positive *sca* effects were observed for 11 hybrids. The *sca* effects for grain yield per plant ranged from -9.00 (APMS 6A x MTU 1229) to 15.31 (APMS 12A x MTU 1156). Further, 13 hybrids (APMS 6A x IR64, APMS 6A x IR 7693-2B-7, APMS 6A x MCM 223, APMS 6A x MCM 48, APMS 6A x MTU 1213, APMS 9A x MTU 1010, APMS 9A x MTU 1229, APMS 9A x MTU 1032, APMS 9A x MCM 48, APMS 12A x MTU 1153, APMS 12A x MTU 1156, APMS 12A x MCM 223 and APMS 12A x MTU 1031) had recorded significant and positive for the *sca* effects for grain yield per plant. A characterization of the parents of these hybrids with respect to their *gca* effects revealed the hybrids to involve either both parents with high or low *gca* or one parent with high and the other with low *gca* effects, indicating the role of additive x additive,

dominance x dominance and additive x dominance type of gene action (Suneetha and Kathiria, 2005). These hybrids need to be evaluated further prior to their commercial exploitation as potential salinity tolerant hybrids.

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