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Combining ability analysis for yield and component traits under saline-alkali soil in rice

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ABSTRACT

Combining ability study on grain yield and component traits from a line × tester analysis of 2 CMS lines and 20 testers, indicated that dominance gene effects were predominant for all the traits viz., seedling height, number of leaves seedling^{-1}, days to 50 percent flowering, flag leaf length, plant height, panicle bearing tillers plant^{-1}, panicle length, spikelets panicle^{-1}, spikelet fertility, grain yield plant^{-1}, test weight and harvest index. The line IR 58025A was found to be a good general combiner for grain yield and component traits. CSRC(S) 14-1-4-0 and IR 64 are also good combiner along with other traits. The tester parents NDRK 5094, IR 72048-B-R-2-2-2-1-B, CSRC(S) 14-1-4-0, NDR 9830119, Narendra Usar 3, 21-2-5-B-1-1, IR 71829-3R-73-1-2-B and IR 64 were judged as good general combiners for grain yield and its components. The crosses NMS 4A × IR 70023-4B-R-12-3-1-1-B, NMS 4A × PNL 1-8-5-17-2, IR 58025A × NDRK 5086, IR 58025A × NDR 9830119, IR 58025A × 21-2-5-B-1-1, NMS 4A × IR 64, NMS 4A × NDR 9830148, IR 58025A × IR 72048-B-R-2-2-2-1-B, NMS 4A × 22-2-B-2-1-1, NMS 4A × NDRK 5094, NMS 4A × 92-H51-4, IR 58025A × Narendra Usar 3 and NMS 4A × CSRC(S) 14-1-4-0 were good specific combinations for grain yield.

Key words: *rice*, *CMS lines*, *combining ability*, *analysis*

Rice is cultivated in 114 of the 193 countries of the world. India is capable of producing 134.15 m t of rice over an area of 44.50 m ha with productivity of 3.01 t ha^{-1} against 6.23 t ha^{-1} of China (Maclean *et al.*, 2002). This difference in productivity is due to the slow development of new exploitable hybrids for various abiotic stresses, as second most important abiotic stress of country is the salt affected soil having 8.9 m ha area out of which 3.4 m ha under sodicity and rest under salinity. Hybrid rice, though a success story in China, is yet to prove its niche in Indian rice production system. At present, hybrid rice research is concentrated on conversion and identification of stable local CMS lines, effective restorer lines and superior combining heterotic hybrids. As the CMS lines from the local elite lines are still under the process of conversion through repeated back crosses, also must be onverted to the background of saline-alkali tolerant genotype. The present study is directed towards selection of suitable parents to produce heterotic hybrids under saline-alkali situation.

MATERIALS AND METHODS

Two CMS lines (IR 58025 A and NMS 4 A) were crossed with 20 well adopted genotypes in saline-alkali situation as pollinator in a line×tester design (Kempthorne, 1957) to generate 40 F_1 combinations. The F_1s and parents were grown with two standard checks at the Research Farm of Narendra Deva University of Agriculture and Technology, Faizabad during the 2006 wet season in a randomized block design with three replications. Each plot consisted of single row of 3 m length with spacing of 20 cm between rows and 15 cm between plants. All the recommended cultural practices were followed to obtain normal growth of the crop. Observations were recorded on five randomly selected plants from each replication for 12 traits using standard evaluation system of IRRI. Standard heterosis of grain yield was estimated as percent gain in grain yield of the hybrids over the standard check Narendra Usar Sankar Dhan 3 (NUSD 3) and Narendra Usar 2.

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RESULTS AND DISCUSSION

The analysis of variance for combining ability revealed significant differences among treatments, parents, crosses, parent *vs.* crosses, lines, testers and lines × testers (Table 1). Significance of parents and hybrids for all the characters indicated wide genetic differences among them. The significant variance due to parents *vs.* crosses indicated prevalence of heterosis for all the characters, except spikelet fertility. The significance of mean squares due to lines and testers indicated prevalence of additive variance for most of the studied characters. The significance of variance due to lines × testers for all the characters provided a direct test indicating that dominance or non-additive variance was important for all studied characters. The comparative variance due to general combining ability and specific combining ability revealed the predominance of non-additive gene action for all the traits (Table 2).

Predominance of non-additive gene action for grain yield and components was also reported by Sarawgi *et al.* (1991), Murthy and Shivshankar (1992), Thirumeni *et al.* (2000) and Singh *et al.* (2005). The CMS line IR 58025 A and testers NDRK 5094, IR 72048-B-R-2-2-2-1-B, CSRC(S) 14-1-4-0, NDR 9830119, Narendra Usar 3, 21-2-5-B-1-1, IR 71829-3R-73-1-2-B and IR 64 were best combiners for grain yield. The CMS line IR 58025 A was also a good general combiner for other yield components (Table 3).

The hybrids IR 58025 A × IR 70023-4B-R-12-3-1-1-B, NMS 4A × 92-H51-4, IR 58025 A × Narendra Usar 3, IR 58025 A × 21-2-5-B-1-1 and IR 58025 A × IR 71829-3R-73-1-2-B recorded significant sca effects for grain yield and other yield components (Table 4). Other hybrids IR 58025 A × IR 72048-B-R-2-2-2-1-B, IR 58025 A × NDR 9830119, NMS 4A × NDRK 5094, NMS 4A × CSRC(S) 14-1-4-0, IR 58025 A × Narendra Usar 3, IR 58025 A × IR 71829-3R-73-1-2-B, IR 58025 A × 21-2-5-B-1-1, IR 58025 A × NDRK 5086 and NMS 4A × IR 64 with significant sca effects and more than 20 percent standard heterosis (Table 5) offers scope for commercial exploitation of heterosis.

Other hybrids with good sca effects like IR 58025 A × NDRK 5086 and NMS 4 A × IR 64 involved high × low combiners suggesting additive and dominance interactions. Peng and Virmani (1990) also reported the possibility of interaction between positive

Table 1. Analysis of variance of line × tester for 12 characters in rice.

Source of variation	DF	Seedling height (cm)	Number of leaves seedling^{-1}	Days to 50% flowering	Flag leaf length (cm)	Plant height (cm)	Panicle bearing tillers plant^{-1}	Panicle length (cm)	Spikelets panicle^{-1}	Spikelet fertility (%)	Grain yield plant^{-1}(g)	Test weight (g)	Harvest index (%)
Replications	2	15.40*	0.40**	38.10*	17.70**	102.96**	40.49**	28.00**	1299.10**	23.72	73.66*	14.54*	134.06**
Treatments	61	258.65**	1.96**	345.08**	108.41**	371.07**	18.45**	26.76**	5470.06**	1405.09**	657.13**	82.08**	393.38**
Parents (P)	21	22.47**	0.14**	269.04**	13.54**	224.60**	11.83**	13.99**	2522.00**	1861.43**	206.74**	133.08**	377.90**
P vs C	1	9592.80**	68.39**	1818.37**	454.35**	1580.34**	83.36**	65.73**	37585.39**	7.04	8226.69**	212.51**	154.88**
Crosses (C)	39	146.49**	1.24**	348.25**	150.62**	418.92**	20.35**	32.64**	6234.01**	1195.22**	705.55**	51.28**	407.83**
Testers (t)	19	171.65*	1.45*	459.30*	196.08*	260.31	14.55	42.60*	7757.98*	1741.81**	807.31	38.26	602.05**
Lines (l)	1	1027.85**	8.68**	1068.03*	777.19**	2489.76**	123.83*	139.97**	28955.07**	4148.46**	2403.52*	270.90*	856.06*
l x t	19	74.93**	0.63**	199.31**	72.19**	468.54**	20.71**	17.04**	3514.20**	493.20**	514.43**	52.74**	190.02**
Error	122	4.13	0.06	8.4	3.27	29.00	3.72	5.80	183.81	31.55	18.94	4.33	12.67
Genetic components	σ^2_A	3.21	0.03	6.68	3.52	2.22	0.02	0.7	121.92	31.47	8.57	0.07	9.76
of variance	σ^2_D	23.6	0.19	63.64	22.97	146.51	5.66	3.74	1110.13	153.88	165.17	16.14	59.12
Predictability ratio	$\sigma^2_{gca}/\sigma^2_{sca}$	0.03	0.04	0.03	0.04	0.00	0.08	0.05	0.03	0.05	0.05	0.02	0.04

Table 2. Estimates of general combining ability (gca) effects of parents for plant characters in rice

Parental lines	Seedling height (cm)		Number of leaves seedling^{-1}		Days to 50% flowering		Flag leaf length (cm)		Plant height (cm)		Panicle bearing tillers plant^{-1}	
Male	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$
IR 61920-3B-22-2-1	-0.64	18.85	-0.06	1.85	21.88**	121.33	8.33**	32.41	14.02**	101.60	-0.52	9.27
IR 70023-4B-R-12-3-1-1-B	-3.61**	18.66	-0.33**	1.72	6.55**	126.33	-3.19**	32.98	6.79**	107.13	-1.10	8.80
PNL 1-8-5-17-2	7.84**	23.11	0.72**	2.12	17.38**	117.00	-1.88*	34.94	1.52	98.30	2.17**	10.00
NDRK 5095	6.13**	24.53	0.56**	2.25	2.55*	125.33	-1.70*	33.81	2.42	96.47	-1.08	11.33
NDRK 5056	-3.89**	19.98	-0.36**	1.84	-5.95**	119.00	-4.36**	32.53	2.40	98.67	1.43	11.07
NDRK 5086	2.70**	21.86	0.25*	2.01	-7.78**	121.67	-0.79	31.02	-2.80	94.13	0.88	9.50
NDR 9830119	-6.83**	22.65	-0.63**	2.08	-10.28**	124.67	3.84**	31.66	-1.03	108.93	-1.15	9.40
NDRK 5013	6.60**	22.07	0.61**	2.03	-3.95**	111.33	-3.00**	33.89	-2.08	103.50	-2.07**	8.00
CST 7-1	-0.06	18.35	-0.01	1.77	6.05**	126.00	-5.09**	31.30	-6.36**	92.70	0.78	7.73
21-2-5-B-1-1	0.74	15.86	0.07	1.67	5.55**	123.67	0.66	34.56	-1.98	108.20	1.12	10.67
IR 64	6.12**	15.21	0.56**	1.62	-7.28**	106.67	-1.11	27.98	-11.25**	100.93	-2.53**	8.23
NDR 9830148	6.80**	23.66	0.62**	2.17	-6.12**	117.67	-3.57**	29.81	5.29*	112.23	-1.27	6.93
CSRC(S) 14-1-4-0	-13.56**	18.23	-1.25**	1.78	2.38*	119.00	4.43**	30.85	-0.46	118.50	0.58	7.87
PNL 5-8-1-7-21	1.93*	17.55	0.18	1.76	-7.12**	117.67	-3.64**	32.47	-12.46**	97.37	1.13	13.20
IR 72048-B-R-2-2-2-1-B	-3.58**	18.95	-0.33**	1.74	1.88	120.67	-3.32**	32.26	-3.05	107.27	3.05**	13.67
IR 71829-3R-73-1-2-B	-1.92*	18.19	-0.18	1.67	-3.62**	126.33	-4.97**	29.91	10.34**	91.20	1.53	10.87
22-2-B-2-1-1	-4.05**	17.02	-0.37**	1.56	-3.12**	122.33	10.19**	35.45	-2.23	107.87	-2.08**	9.90
NDRK 5094	0.58	20.23	0.05	2.25	4.55**	119.67	0.35	31.82	6.77**	98.67	-1.43	10.73
92-H 51-4	-3.13**	21.74	-0.29**	2.00	-11.95**	123.33	15.36**	36.65	-0.08	95.47	-0.28	10.00
Narendra Usar 3	1.86	22.18	0.17	2.04	-1.62	116.67	-6.54**	34.07	-5.76**	98.40	0.82	11.93
SE (gi)	0.83	1.66	0.10	0.20	1.18	2.37	0.74	1.48	2.20	4.40	0.79	1.57
Female												
NMS 4A	-2.93**	18.15	-0.27**	2.12	2.98**	96.33	-2.54**	31.34	-4.56**	90.27	-1.02**	12.83
IR 58025 A	2.93**	15.30	0.27**	2.16	-2.98**	89.33	2.54**	29.39	4.56**	78.90	1.02**	13.93
SE (gj)	0.26	1.66	0.03	0.20	0.37	2.37	0.23	1.48	0.70	4.40	0.25	1.57

Table 3. Estimates of specific combining ability (sca) effects of hybrids for yield and yield attributes in rice

Parental lines	Panicle length (cm)		Spikelets panicle^{-1} (%)		Spikelet fertility		Grain yield plant^{-1} (g)		Test weight (g)		Harvest index (%)	
Male	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$
IR 61920-3B-22-2-1	-1.47	22.93	-44.37**	133.63	-10.63**	79.38	-6.53**	15.56	-6.96**	20.14	-24.09**	39.27
IR 70023-4B-R-12-3-1-1-B	3.28**	26.47	-51.33**	123.20	-7.37**	84.59	-14.58**	15.25	-0.34	18.93	-0.94	37.31
PNL 1-8-5-17-2	-5.55**	21.87	20.47**	143.53	19.33**	83.88	-3.34	22.42	0.81	20.32	-0.1	39.96
NDRK 5095	0.73	27.63	-46.22**	175.40	-19.12**	85.93	-2.41	22.36	3.46**	22.42	6.53**	31.69
NDRK 5056	-1.08	24.53	3.25	160.63	7.02**	86.50	2.23	21.54	-0.69	17.20	10.75**	34.52
NDRK 5086	-2.28*	21.97	-10.83	176.53	-21.47**	81.56	-4.10*	25.00	-0.16	19.28	6.40**	35.32

Table 3 contd.....

Parental lines	Panicle length (cm)		Spikelets panicle^{-1} (%)		Spikelet fertility		Grain yield plant^{-1} (g)		Test weight (g)		Harvest index (%)	
Male	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$	gca	$\bar{X}$
NDR 9830119	2.15*	24.40	14.92**	220.87	8.55**	87.71	11.15**	32.21	1.75*	19.40	5.65**	35.56
NDRK 5013	-0.28	22.87	-44.65**	104.97	-21.67**	74.60	-19.29**	20.89	1.45	25.45	-1.86	37.88
CST 7-1	-0.03	22.60	2.62	128.07	-2.15	79.46	2.65	11.58	3.08**	21.58	-14.71**	38.61
21-2-5-B-1-1	2.03*	21.63	25.25**	157.07	8.62**	73.50	7.05**	22.47	1.27	21.81	4.95**	35.96
IR 64	-3.17**	22.70	30.38**	145.43	4.74*	90.69	3.62*	20.84	-1.91*	25.11	5.09**	42.05
NDR 9830148	3.98**	24.73	-15.02	173.30	16.11**	69.43	-2.54	15.21	2.84**	22.87	6.08**	31.70
CSRC(S) 14-1-4-0	-1.57	24.43	18.08**	173.57	-7.61**	75.90	14.85**	23.40	0.19	22.41	-8.91**	40.20
PNL 5-8-1-7-21	-1.13	23.30	43.87**	147.70	11.58**	88.99	-1.11	26.53	1.31	21.80	-1.67	37.13
IR 72048-B-R-2-2-2-1-B	2.55*	29.50	4.22	124.90	15.55**	64.13	15.99**	20.94	-0.39	20.87	5.65**	36.76
IR 71829-3R-73-1-2-B	1.92	23.13	15.77**	158.80	17.14**	56.43	6.88**	15.72	1.74*	16.16	9.38**	36.90
22-2-B-2-1-1	-0.27	24.63	-57.18**	164.23	-8.87**	77.63	-10.07**	18.13	-3.57**	16.64	1.52	31.32
NDRK 5094	3.47**	22.53	39.35**	167.73	14.78**	85.04	16.62**	24.92	-0.15	23.99	5.01**	37.17
92-H 51-4	-4.65**	27.50	-22.28**	180.57	-42.85**	84.79	-26.44**	26.76	-3.71**	23.54	-22.35**	28.39
Narendra Usar 3	1.37	24.10	73.75**	205.07	18.29**	85.29	9.37**	33.04	-0.03	18.08	7.62**	40.60
SE (gi)	0.98	1.97	5.53	11.07	2.29	4.59	1.17	3.55	0.85	1.70	1.45	2.91
Female												
NMS 4A	-1.08**	27.20	-15.53**	190.06	-5.88**	0.00	-4.48**	0.00	-1.50**	0.00	-2.67**	0.00
IR 58025 A	1.08**	22.63	15.53**	201.59	5.88**	0.00	4.48**	0.00	1.50**	0.00	2.67**	0.00
SE (gj)	0.31	1.97	1.75	11.07	0.73	4.59	0.56	3.55	0.27	1.70	0.46	2.91

*, ** significant at 5% and 1% levels, respectively.

Table 4. Estimates of specific combining ability (sca) effects of hybrids for plant characters in rice.

Hybrids	Seedling height (cm)		Number of leaves seedling^{-1}		Days to 50% Flowering		Flag leaf length (cm)		Plant height (cm)		Panicle bearing tillers plant^{-1}	
	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$
NMS 4A × IR 61920-3B-22-2-1	4.44**	35.53	0.41**	3.27	-3.48*	132.67	-5.20**	36.18	2.47	118.33	-0.83	9.30
IR 58025 A × IR 61920-3B-22-2-1	-4.44**	32.50	-0.41**	2.99	3.48*	133.67	5.20**	51.66	-2.47	122.50	0.83	13.00
NMS 4A × IR 70023-4B-R-12-3-1-1-B	-0.45	27.67	-0.04	2.54	3.85*	124.67	-5.66**	24.19	-8.63**	100.00	-1.02	8.53
IR 58025 A × IR 70023-4B-R-12-3-1-1-B	0.45	34.42	0.04	3.16	-3.85*	111.00	5.66**	40.60	8.63**	126.37	1.02	12.60
NMS 4A × PNL 1-8-5-17-2	-0.93	38.64	-0.09	3.55	0.02	131.67	1.27	32.43	12.21**	115.57	2.35*	15.17
IR 58025 A × PNL 1-8-5-17-2	0.93	46.36	0.09	4.26	-0.02	125.67	-1.27	34.99	-12.21**	100.27	-2.35*	12.50
NMS 4A × NDRK 5095	-1.98	35.88	-0.18	3.30	9.52**	126.33	1.88	33.23	-6.06	98.20	-0.50	9.07
IR 58025 A × NDRK 5095	1.98	45.69	0.18	4.20	-9.52**	101.33	-1.88	34.55	6.06	119.43	0.50	12.10
NMS 4A × NDRK 5056	0.65	28.49	0.06	2.62	-5.32**	103.00	-2.74**	25.94	14.16**	118.40	-1.48	10.60
IR 58025 A × NDRK 5056	-0.65	33.05	-0.06	3.04	5.32**	107.67	2.74**	36.52	-14.16**	99.20	1.48	15.60

Table 4 contd.....

Hybrids	Seedling height (cm)		Number of leaves seedling^{-1}		Days to 50% Flowering		Flag leaf length (cm)		Plant height (cm)		Panicle bearing tillers plant^{-1}	
	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$
NMS 4A × NDRK 5086	2.24	36.67	0.21	3.37	0.85	107.33	2.35*	34.60	-8.78**	90.27	-2.23*	9.30
IR 58025 A × NDRK 5086	-2.24	38.05	-0.21	3.50	-0.85	99.67	-2.35*	34.99	8.78**	116.93	2.23*	15.80
NMS 4A × NDR 9830119	2.51*	27.41	0.23	2.52	-1.65	102.33	-6.96**	29.92	-6.61*	94.20	0.30	9.80
IR 58025 A × NDR 9830119	-2.51*	28.24	-0.23	2.60	1.65	99.67	6.96**	48.93	6.61*	116.53	-0.30	11.23
NMS 4A × NDRK 5013	-6.00**	32.34	-0.55**	2.97	-10.98**	99.33	3.30**	33.34	-8.63**	91.13	2.48*	11.07
IR 58025 A × NDRK 5013	6.00**	50.19	0.55**	4.61	10.98**	115.33	-3.30**	31.83	8.63**	117.50	-2.48*	8.13
NMS 4A × CST 7-1	-5.93**	25.74	-0.55**	2.37	7.35**	127.67	1.76	29.71	15.46**	110.93	-0.33	11.10
IR 58025 A × CST 7-1	5.93**	43.46	0.55**	3.99	-7.35**	107.00	-1.76	31.28	-15.46**	89.13	0.33	13.80
NMS 4A × 21-2-5-B-1-1	-6.07**	26.41	-0.56**	2.43	7.52**	127.33	-1.77	31.93	-9.16**	90.70	-2.57*	9.20
IR 58025 A × 21-2-5-B-1-1	6.07**	44.40	0.56**	4.08	-7.52**	106.33	1.77	40.57	9.16**	118.13	2.57*	16.37
NMS 4A × IR 64	-2.39*	35.47	-0.22	3.26	-1.65	105.33	2.79**	34.72	2.94	93.53	1.48	9.60
IR 58025 A × IR 64	2.39*	46.10	0.22	4.24	1.65	102.67	-2.79**	34.23	-2.94	96.77	-1.48	8.67
NMS 4A × NDR 9830148	3.80**	42.33	0.35*	3.89	-8.82**	99.33	1.86	31.33	-6.46*	100.67	2.95**	12.33
IR 58025 A × NDR 9830148	-3.80**	40.58	-0.35*	3.73	8.82**	111.00	-1.86	32.71	6.46*	122.70	-2.95**	8.47
NMS 4A × CSRC(S) 14-1-4-0	3.43**	21.61	0.32*	1.99	10.02**	126.67	0.73	38.20	-10.88**	90.50	3.50**	14.73
IR 58025 A × CSRC(S) 14-1-4-0	-3.43**	20.59	-0.32*	1.89	-10.02**	100.67	-0.73	41.83	10.88**	121.37	-3.50**	9.77
NMS 4A × PNL 5-8-1-7-21	-1.43	32.24	-0.13	2.96	1.18	108.33	1.39	30.79	7.32*	96.70	0.98	12.77
IR 58025 A × PNL 5-8-1-7-21	1.43	40.95	0.13	3.76	-1.18	100.00	-1.39	33.09	-7.32*	91.17	-0.98	12.83
NMS 4A × IR 72048-B-R-2-2-2-1-B	4.72**	32.87	0.43**	3.02	1.18	117.33	1.41	31.13	4.47	103.27	1.17	14.87
IR 58025 A × IR 72048-B-R-2-2-2-1-B	-4.72**	29.28	-0.43**	2.69	-1.18	109.00	-1.41	33.41	-4.47	103.43	-1.17	14.57
NMS 4A × IR 71829-3R-73-1-2-B	0.82	30.63	0.08	2.81	-0.32	110.33	2.14*	30.22	8.96*	121.13	-2.48*	9.70
IR 58025 A × IR 71829-3R-73-1-2-B	-0.82	34.85	-0.08	3.20	0.32	105.00	-2.14*	31.02	-8.96*	112.33	2.48*	16.70
NMS 4A × 22-2-B-2-1-1	-1.90	25.79	-0.17	2.37	-4.15*	107.00	3.03**	46.26	-3.65	95.97	-0.03	8.53

Table 4 contd.....

Hybrids	Seedling height (cm)		Number of leaves seedling^{-1}		Days to 50% Flowering		Flag leaf length (cm)		Plant height (cm)		Panicle bearing tillers plant^{-1}	
	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$
IR 58025 A × 22-2-B-2-1-1	1.90	35.44	0.17	3.26	4.15*	109.33	-3.03**	45.30	3.64	112.37	0.03	10.63
NMS 4A × NDRK 5094	1.16	33.48	0.11	3.08	3.52*	122.33	-4.94**	28.46	5.69	114.30	-0.68	8.53
IR 58025 A × NDRK 5094	-1.16	37.01	-0.11	3.40	-3.52*	109.33	4.94**	43.43	-5.69	112.03	0.68	11.93
NMS 4A × 92-H 51-4	-1.92	26.69	-0.18	2.45	-3.98*	98.33	5.30**	53.71	-10.13**	91.63	-0.73	9.63
IR 58025 A × 92-H 51-4	1.92	36.37	0.18	3.34	3.98*	100.33	-5.30**	48.19	10.13**	121.00	0.73	13.13
NMS 4A × Narendra Usar 3	5.21**	38.81	0.48**	3.57	-4.65**	108.00	-1.94	24.56	5.32	101.40	-2.30*	9.17
IR 58025 A × Narendra Usar 3	-5.21**	34.23	-0.48**	3.15	4.65**	111.33	1.94	33.54	-5.32	99.87	2.30*	15.80
SE (Sij)	1.17		0.14		1.67		1.04		3.11		1.11	

alleles from good combiners and negative alleles from poor combiners in high × low combiner crosses and suggested for the exploitation of heterosis in F_1 generation as their high yield potential would be unfixable in succeeding generations.

Seven hybrids namely IR 58025 A × IR 72048-B-R-2-2-2-1-B, IR 58025 A × NDR 9830119, NMS 4A × NDRK 5094, NMS 4A × CSRC(S) 14-1-4-0, IR 58025 A × Narendra Usar 3, IR 58025 A × IR 71829-3R-73-1-2-B and IR 58025 A × 21-2-5-B-1-1 with good sca effects for grain yield involved high × high combining parents, indicating additive×additive type of interactions (Table 4). Manuel and Palanisamy (1989) also reported about interaction between positive and positive allele in crosses involving high×high combiners which can be fixed in subsequent generations if no repulsion phase and linkages were involved.

Table 5. Estimates of specific combining ability (sca) effects of hybrids for yield and yield attributes in rice.

Hybrids	Panicle length (cm)		Spikelets panicle^{-1}		Spikelet fertility (%)		Grain yield plant^{-1} (g)		Test weight (g)		Harvest index (%)	
	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$
NMS 4A × IR 61920-3B-22-2-1	-0.87	22.07	-2.88	128.60	-6.26	49.35	3.55	26.21	0.9	13.67	3.15	7.58
IR 58025 A × IR 61920-3B-22-2-1	0.87	25.97	2.88	165.43	6.26	73.62	-3.55	28.06	-0.9	14.87	-3.15	6.63
NMS 4A × IR 70023-4B-R-12-3-1-1-B	0.11	27.80	45.82**	170.33	12.73**	71.59	8.70**	23.30	6.32**	25.71	11.46**	39.04
IR 58025 A × IR 70023-4B-R-12-3-1-1-B	-0.11	29.73	-45.82**	109.77	-12.73**	57.90	-8.70**	14.85	-6.32**	16.07	-11.46**	21.47
NMS 4A × PNL 1-8-5-17-2	-0.29	18.57	36.45**	232.77	5	90.56	6.19*	32.03	-0.22	20.32	-7.17**	21.25

Table 5 contd.....

Hybrids	Panicle length (cm)		Spikelets panicle^{-1}		Spikelet fertility (%)		Grain yield plant^{-1} (g)		Test weight (g)		Harvest index (%)	
	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$
IR 58025 A × PNL 1-8-5-17-2	0.29	21.30	-36.45**	190.93	-5	92.33	-6.19*	28.60	0.22	23.77	7.17**	40.94
NMS 4A × NDRK 5095	-3.54*	21.60	-2.47	127.17	-10.21**	36.91	-5.14*	21.63	1.03	24.23	1.55	36.61
IR 58025 A × NDRK 5095	3.54*	30.83	2.47	163.17	10.21**	69.09	5.14*	40.87	-1.03	25.17	-1.55	38.84
NMS 4A × NDRK 5056	-0.52	22.80	-15	164.10	-7.83*	65.43	-0.87	30.55	-0.6	18.43	-2.1	37.17
IR 58025 A × NDRK 5056	0.52	26.00	15	225.17	7.83*	92.84	0.87	41.24	0.6	22.65	2.1	46.72
NMS 4A × NDRK 5086	-1.52	20.60	11.08	176.10	5.62	50.39	-12.01**	13.08	-3.00*	16.58	-6.92**	28.01
IR 58025 A × NDRK 5086	1.52	25.80	-11.08	185.00	-5.62	50.90	12.01**	46.05	3.00*	25.58	6.92**	47.19
NMS 4A × NDR 9830119	-0.12	26.43	-26.47**	164.30	-5.24	69.54	-13.68**	26.66	2.12	23.60	5.14*	39.31
IR 58025 A × NDR 9830119	0.12	28.83	26.47**	248.30	5.24	91.79	13.68**	62.96	-2.12	22.37	-5.14*	34.39
NMS 4A × NDRK 5013	-2.09	22.03	-8.17	123.03	-11.52**	33.04	-3.04	6.85	-2.48*	18.71	-3.21	23.45
IR 58025 A × NDRK 5013	2.09	28.37	8.17	170.43	11.52**	67.85	3.04	21.89	2.48*	26.67	3.21	35.22
NMS 4A × CST 7-1	-0.47	23.90	-28.57**	149.90	-15.45**	48.63	-0.51	31.32	-0.87	21.94	-1.08	12.74
IR 58025 A × CST 7-1	0.47	27.00	28.57**	238.10	15.45**	91.29	0.51	41.30	0.87	26.68	1.08	20.24
NMS 4A × 21-2-5-B-1-1	-1.9	24.53	-48.43**	152.67	-4.8	70.06	-5.07*	31.17	-2.93*	18.07	-7.80**	25.68
IR 58025 A × 21-2-5-B-1-1	1.9	30.50	48.43**	280.60	4.8	91.42	5.07*	50.26	2.93*	26.93	7.80**	46.62
NMS 4A × IR 64	1.83	23.07	6.23	212.47	-8.76**	62.22	12.72**	45.52	5.83**	23.65	2.99	36.60
IR 58025 A × IR 64	-1.83	21.57	-6.23	231.07	8.76**	91.50	-12.72**	29.04	-5.83**	15.00	-2.99	35.97
NMS 4A × NDR 9830148	0.88	29.27	19.07*	179.90	2.97	85.32	6.58*	33.22	3.93**	26.50	3.84	38.44
IR 58025 A × NDR 9830148	-0.88	29.67	-19.07*	172.83	-2.97	91.14	-6.58*	29.02	-3.93**	21.64	-3.84	36.11
NMS 4A × CSRC(S) 14-1-4-0	-0.17	22.67	9.63	203.56	4.28	62.90	10.32**	54.36	-2.21	17.71	-0.21	19.41
IR 58025 A × CSRC(S) 14-1-4-0	0.17	25.17	-9.63	215.37	-4.28	66.10	-10.32**	42.67	2.21	25.14	0.21	25.17
NMS 4A × PNL 5-8-1-7-21	1.26	24.53	10.88	230.60	-1.41	76.40	-4.41	23.66	1.09	22.13	0.09	26.95
IR 58025 A × PNL 5-8-1-7-21	-1.26	24.17	-10.88	239.90	1.41	90.99	4.41	41.44	-1.09	22.96	-0.09	32.11
NMS 4A × IR 72048-B-R-2-2-2-1-B	-0.05	26.90	-37.33**	142.73	0.8	82.58	-19.95**	25.23	-2.88*	16.46	-1.53	32.65

Table 5 contd.....

Hybrids	Panicle length (cm)		Spikelets panicle^{-1}		Spikelet fertility (%)		Grain yield plant^{-1} (g)		Test weight (g)		Harvest index (%)	
	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$	sca	$\bar{X}$
IR 58025 A × IR 72048-B-R-2-2-2-1-B	0.05	29.17	37.33**	248.47	-0.8	92.74	19.95**	74.08	2.88*	25.23	1.53	41.05
NMS 4A × IR 71829-3R-73-1-2-B	0.61	26.93	20.35*	211.97	2.34	85.72	-6.02*	30.05	-3.34**	18.13	-5.77**	32.13
IR 58025 A × IR 71829-3R-73-1-2-B	-0.61	27.87	-20.35*	202.33	-2.34	92.79	6.02*	51.03	3.34**	27.82	5.77**	49.01
NMS 4A × 22-2-B-2-1-1	4.70**	28.83	12.37	131.03	22.03**	79.39	10.58**	29.70	0.52	16.68	7.15**	37.20
IR 58025 A × 22-2-B-2-1-1	-4.70**	21.60	-12.37	137.37	-22.03**	47.09	-10.58**	17.48	-0.52	18.65	-7.15**	28.24
NMS 4A × NDRK 5094	0.9	28.77	19.80*	235.00	0.76	81.78	11.63**	57.43	-2.48*	17.11	-1.28	32.26
IR 58025 A × NDRK 5094	-0.9	29.13	-19.80*	226.47	-0.76	92.01	-11.63**	43.12	2.48*	25.07	1.28	40.16
NMS 4A × 92-H 51-4	0.75	20.50	-21.00**	132.57	9.36**	32.75	7.15**	9.89	2.3	18.32	9.28**	15.46
IR 58025 A × 92-H 51-4	-0.75	21.17	21.00**	205.63	-9.36**	25.78	-7.15**	4.54	-2.3	16.73	-9.28**	2.24
NMS 4A × Narendra Usar 3	0.5	26.27	-1.37	248.23	5.58	90.11	-6.71**	31.85	-3.03*	16.67	-7.57**	28.58
IR 58025 A × Narendra Usar 3	-0.5	27.43	1.37	282.03	-5.58	90.70	6.71**	54.22	3.03*	25.74	7.57**	49.06
SE (Sij)	1.39		7.83		3.24		2.51		1.2		2.05	

*, ** significant at 5% and 1% levels, respectively.

In present study, it is revealed that heterotic hybrids with high sca effects alongwith high *per se* performance involving high×high parental gca combination can be utilized for isolation of transgressive segregants through selection in segregating generations. However, high×low combining heterotic hybrids may be exploited for heterosis breeding to boost up rice production from the harsh saline-alkali prone areas of the country.

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