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Combining ability for yield and it attributes in paddy

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Abstract

Combining ability studies for grain yield and its component traits in 48 crosses and their 16 parents (12 male and 4 CMS) mated in Line × Testers matting design. Combining ability revealed higher specific combining ability variance than their respective general combining ability variances indicating the predominance of non-additive gene effects indicated relevance of hybrid breeding programme for improving the yield and it’s contributing attributes. Among the lines CMS 6A and CMS 15A while among testers R5, R1, R7, R12 and R4, were good general combiners for yield and other related components, thus these were utilize as potential donor. Among these R5 showed good GCA for majority of the yield enhancing traits except days to 50% flowering. Out of 48crosses, two crosses viz. CMS 4A × R10 and CMS 14A × R10 were identified to exploit heterosis in positive direction with desirable SCA effects and high *per se* performance for yield and other traits and were found significantly desirable cross combination for heterosis breeding.

Keywords: Genotypic and phenotypic variation, GCA, SCA.

Introduction

Rice (*Oryza sativa* L.) is the most important staple food crop of the world, and major source of calories of more than half of the global population. More than 90 per cent of the world’s rice is grown and consumed in Asia, known as rice bowl of the world, where 60 per cent of the earth’s people and two third of world’s poor live (Khush and Virk, 2000) [6]. To focus attention on the importance of rice in global food security and the necessity to increase rice production and productivity, United Nations General Assembly in 2002 declared to celebrate the year 2004 as “International Year of Rice (IYR 2004)” with the theme of “Rice is Life”. Government of India launched national food security mission during 2007 to enhance rice production. In order to keep pace with growing population, the estimated rice requirement by 2025 is about 130 metric tons. The use of high yielding semi dwarf rice varieties has increased the production but from a decade the further increase in production has became difficult due to planting of yield levels. This necessitates innovative breeding techniques. Among the viable and adaptable options hybrid rice technology is practically feasible because in china the yield levels raised from 3.0 tons to 6.0 tons per hector by adopting hybrid rice technology. Technical support from IRRI Philippines and keen interest by Government of India has leaded the Indian scientist to make some achievement in developing hybrids. Combining ability analysis is useful technique for understanding of genetic worth of parents and their crosses for further exploitation in breeding programmes. The present study, therefore, aims to study the combining ability of parents and crosses and gene action for grain yield and its components.

Methods and Material

The present investigation combining ability was based on evaluation of a line x tester set of 48 hybrids (F_1’s) and their 16 parents for seven characters under normal sown and irrigated condition in randomized block design with three replications during *Kharif*, 2018, carried out at the Research Farm of Bhagwant University, Ajmer, Rajasthan. The crosses were made during *Kharif*, 2017 and the hybrids along with parental lines were evaluated during *Kharif*,

2018. The data on seven characters was subjected to analysis of variance for randomized block design (Panse and Sukhtame, 1967), heritability in broad sense (Hanson *et al.*, 1956) and genetic advance in per cent of mean (Johnson *et al.*, 1955), line x tester analysis of combining ability (Kempthorne, 1957) [5] and computation of heterosis over better-parent and mid parent (Kempthorne, 1957) [5]. Four cytoplasmic male sterile lines *viz*., CMS 4A, CMS 6A, CMS 14A and CMS 15A were crossed with twelve genetically rice pollen parents (testers) were R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11 and R12.

Results and Discussion

The analysis of variance revealed highly significant mean squares due to genotypes for six characters except 1000 grain weight show significant (Table-1). Analysis of variance for line x tester revealed highly significant for parents, lines, testers, lines *vs* testers, crosses and parents *vs* crosses for the six characters while significant for 1000 grain weight (Table-2). This indicated presence of substantial variability in the material and validated further statistical and genetical analysis for assessment of genetic variability the estimates of coefficients of variation (Burton and de Vane, 1953) [1].

The analysis of variance for combining ability for seven characters is presented in Table 3, while estimates of components of genetic variance and other genetic parameters are given in Table 4. In the present study, the analysis of variance for combining ability revealed significant differences among the testers for all the characters under study indicating importance of general combining ability and additive gene effects in expression of characters. The mean squares due to lines x tester's interactions, representing importance of specific combining ability and non-additive gene effects, was found to be significant for the all characters under study. The above discussion suggests importance of both additive and non-additive gene effects represented by general and specific combining ability variances, respectively, for majority of characters. The estimates of sca variance were higher than the corresponding estimates of GCA variance for all the. The values of average degree of dominance were more than unity (>1) revealing over dominance for grain yield per plant, number of grains per panicle, plant height and days to 50% flowering, while lesser than unity (<1) estimates of this parameter recorded for productive tillers per plant, panicle length and 1000 grain weight indicated partial dominance. The predictability ratio was lesser than one for all the characters studied. The significant variances due to testers and lines x testers for all the traits revealed importance of additive gene effects for all the characters. However, higher sca variance than corresponding GCA variance for all the characters indicated predominance of non-additive gene effects represented by sca variances. The greater than one or equal to unity estimates of average degree of dominance recorded for most of the characters further emphasized predominance of non-additive gene effects. The lesser than one the predictability ratio also suggested predominance of non-additive gene effects. The importance of additive as well as non-additive gene effects with predominance of non-additive gene effects in inheritance of grain yield and yield components of rice has also been reported earlier by Pradhan *et al*. (2006) [9] Rashid *et al*. (2008); Saleem *et al*. (2010) [15]; Saidaiah *et al.*(2010). The predominance of non-additive gene effects representing non-fixable dominance and epistatic components of genetic variance indicated that maintenance of heterozygocity would be highly fruitful for improving the characters. Hence, the suitable breeding strategy for attaining high yield would be the full or partial exploitation of heterosis through development of hybrid, synthetic or composite cultivars. The non-additive gene effects may also be exploited to some extent for improving the characters by resorting to breeding methods such as biparental mating followed by recurrent selection and population improvement methods as suggested by Jensen (1970) and Redden and Jensen (1974) [13].

Considering the estimates of heritability in narrow sense reflecting important of fixable additive gene effects (Table-4), the high narrow sense heritability recorded for plant height and days to 50% flowering, emerge as traits for which selection would be highly effective and efficient. The moderate narrow sense heritability is observed for productive tillers per plant, panicle length and number of grains per panicle indicated that these traits are unlikely to provide reasonable selection response. Grain yield and 1000 grain weight showed low narrow sense heritability to emerge as poor index for improvement through selection.

The significant and positive gca effects for grain yield per plant were exhibited by 5 testers *viz.*, R1, R4, R5, R7 and R12 and 2 CMS lines which were and CMS 6A and CMS 15 A among lines (Table-5). The parent with highest GCA effects for grain yield, R5, also showed significant GCA effects for short stature, productive tillers, and grains per panicle and 1000-grain weight. R1, R7 and R 4 emerged as good general combiner for grain yield, grain per panicle, short stature and early flowering. R 10 recorded significant and desirable GCA effects for short stature, and early flowering appeared goor general combiner. R12 emerged as good general combiner for grain yield but poor combiner for early flowering, short stature and grains per panicle. R2 and R3 was identified as good general combiner for early flowering and short stature and poor general combiner for grain yield per plant.

Among the two CMS lines exhibiting significant and positive GCA effects for grain yield per plant, CMS 6A was good general combiner for short stature and productive tillers per hill poor general combiner for early flowering and panicle length. CMS 15A needs special attention because it may be valuable for developing fine grain rice hybrids because it was good general combiner for yield components like short stature, early flowering, productive tillers per hill and grains per panicle. The parents showing positive and significant gca effects for grain yield and other important traits as mentioned in above may serve as valuable parents for hybridization programme or multiple crossing programme for obtaining high yielding hybrid varieties or transgressive segregants for developing pure line varieties of rice reported by Lavanya, C. (2000) [7]; Raut *et al.* (2009) [10]; Rajkumar S and Ibrahim S. M. (2013) [12].

The specific combining ability (sca) effects, which are supposed to be manifestation of non-additive components of genetic variance, are highly valuable for discrimination of crosses for their genetic worth as breeding materials. The estimates of sca effects of 48 crosses for 7 characters are given in Table-6. The most promising specific cross combinations for different characters along with their mean performance and GCA effects of parents are listed in Table 7. In study, none of the crosses showed significant sca effects in desirable direction for all the characters. Several crosses exhibited significant and desirable sca effects for one or more characters. Twenty crosses, showed significant and positive sca effects for grain yield per plant as well as some other yield components in which CMS 4A × R10 also exhibits significant and positive sca effects for all characters. CMS 14A × R9, showed significant and positive sca effect for all characters except panicle length and 1000 grain weight. The cross having highest positive and significant sca effects for grain yield per plant viz. CMS 4A × R10 and CMS 14A × R2 and CMS 15A × R8CMS 4A × R12 also recorded significant sca effects in desirable direction productive tillers per hill, panicle length, grains per panicle and 1000 grain weight. The twenty crosses having positive and desirable sca effects for grain yield and some of its component traits merit attention in breeding programme for exploitation of hybrid cultivars.

In general, the crosses showing significant and desirable sca effects were associated with better *per se* performance for respective traits. However, the crosses having high sca effects in desirable direction did not always have high mean performance for the character in question. Thus, the sca effect of the crosses may not be directly related to their *per se* performance. This may be attributed to the fact that *per se* performance is a realized value whereas sca effect is an estimate of F_1 performance over parental one. Therefore, both *per se* performance along with sca effects should be considered for evaluating the superiority of a cross although the former may be more important if development of F_1 hybrids is the ultimate objective suggested by Lavanya, C. (2000); Rashid *et al.* (2007) [11]; Raut *et al.* (2009) [10]; Rajkumar S and Ibrahim S. M. (2013) [12]. The most promising five crosses having significant and desirable sca effects for different character are listed along with their mean performance and GCA effects their parents in Table 7. The crosses may be considered for further utilization owing to their higher genetic worth. The critical examination of Table 7 would reveal that the crosses exhibiting high order significant and desirable sca effects for different characters involved parents having all types of combinations of gca effects such as high × high (H × H), high × average (H × A), high × low (H × L), average × average (A × A), average × low (A × L) and low × low (L × L) general combiner parents. The foregoing observation clearly indicated that there was no particular relationship between positive and significant sca effects of crosses with GCA effects of their parents for the characters under study.

Table 1: Analysis of variance for Randomized block design for 7 characters in rice

Characters d. f.	**Sources of variation**		
	Replications	**Treatments**	**Error**
	2	**63**	**126**
Days to 50% flowering	27.224*	685.151**	51.758
Plant height (cm)	92.512*	901.418**	118.720
Number of Productive tillers per hill	7.036**	21.089**	2.063
Panicle length (cm)	0.317*	26.325**	0.265
Number of grains per panicle	319.514**	817.834**	72.444
1000- grain weight (g)	0.197	6.358*	2.327
Grain yield per plant(g)	25.747**	130.160**	0.513

*, ** Significant at 5% and 1% probability levels, respectively.

Table 2: Analysis of variance for 7 characters of line × tester set of crosses and their parents in rice

Characters Df:	**Sources of variation**							
	Replications	**Parents**	**Lines**	**Testers**	**Lines *vs* testers**	**Crosses**	**Parents *vs* Crosses**	**Error**
	2	15	3	11	1	47	1	126
Days to 50% flowering	27.224**	220.543**	211.889**	285.846**	414.174**	59.071**	408.016**	51.758
Plant height (cm)	9.512*	784.261**	14.889**	514.455**	110.250**	802.444**	260.565**	6.720
Number of Productive tillers per hill	7.036*	21.765**	10.528**	25.414**	15.340**	13.404**	372.168**	2.063
Panicle length (cm)	0.317	64.020**	1.156*	79.957**	77.297**	11.464**	159.372**	0.265
Number of grains per panicle	850.942**	1792.809**	7839.809**	1140.755**	131.673**	1196.426**	168.826**	174.50
1000- grain weight (g)	0.197	7.057*	5.443*	7.874*	2.917*	6.248*	1.081*	2.327
Grain yield per plant (g)	159.747**	4 289.333**	6562.750**	5279.755**	7005.444**	43243.346**	3989.796**	346.513

*, ** Significant at 5% and 1% probability levels, respectively.

Table 3: Analysis of variance for combining ability following line × tester mating design for 7 characters in rice

Characters d.f.	**Sources of variation**				
	Replications	**Lines**	**Testers**	**Lines × Testers**	**Error**
	2	**3**	**11**	**33**	**94**
Days to 50% flowering	6.271*	95.130**	152.894**	24.519**	8.640
Plant height (cm)	817.191**	1736.307**	8326.300**	883.171**	158.412
Number of Productive tillers per hill	8.840*	7.361*	30.588**	8.225*	2.521
Panicle length (cm)	0.390*	11.524**	18.488**	9.118*	0.197
Number of grains per panicle	452.886**	3521.299**	798.451**	1237.608**	209.873
1000- grain weight (g)	0.643*	3.246*	8.810*	5.666*	3.022
Grain yield per plant(g)	1472.808**	4897.052**	2197.218**	14924.052**	444.700

*, ** Significant at 5% and 1% probability levels, respectively.

Table 4: Components of genetic variance, average degree of dominance, predictability ratio and heritability in broad sense for 7 characters in rice

Characters	Gca variance ($\sigma^2 g$)	Sca variance ($\sigma^2 s$)	Average degree of dominance $\sqrt{\sigma^2 s/2\sigma^2 g}$	Predictability ratio $2\sigma^2 g/(2\sigma^2 g+\sigma^2 s)$	$\sigma^2 A$	$\sigma^2 D$	Heritability ($h^2 b$ %)
Days to 50% flowering	4.146	5.293	3.312	0.610	8.291	5.293	8.421
Plant height	194.172	8.253	28.306	0.979	388.344	8.253	50.479
Productive tillers per plant	0.448	1.901	0.653	0.320	0.896	1.901	78.735
Panicle length	0.245	2.974	0.604	0.141	0.491	2.974	21.382
Number of grains per panicle	34.076	354.367	77.703	0.161	68.151	354.367	14.178
1000- grain weight	0.015	0.881	0.081	0.033	0.030	0.881	21.994
Grain yield per plant	27.483	719.784	99.453	0.071	774.965	319.784	21.858

- Negative estimates, @ $h^2 n$ value not calculated due to negative estimate of $\sigma^2 g$ i.e. $\sigma^2 A$ = Zero

Table 5: Estimates of general combining ability (GCA) effects of parents (lines and testers) for 7 characters in rice

S. No.	Testers	Days to 50% flowering	Plant height	Productive tillers per hill	Panicle length	Number of grains per panicle	1000-Grain wt.	Grain yield per plant
1	R 1	-1.417**	-5.719**	0.097	1.473**	12.04**	0.890	841.164**
2	R 2	-7.250**	-9.219**	-2.403**	-0.027	-4.76**	0.424	-755.944**
3	R 3	-1.417**	-14.969**	1.347**	-3.027**	-0.046	-0.776	-751.244**
4	R 4	-4.333**	-2.219**	1.097**	1.473**	9.32**	-0.260	460.956**
5	R 5	-0.667	-7.969**	1.347**	0.473	26.68**	1.415**	1347.906**
6	R 6	1.250**	-4.469**	-2.653**	0.223	2.71**	-0.693	-2840.786**
7	R 7	-5.333**	-9.469**	0.847	0.223	8.99**	-0.036	505.364**
8	R 8	2.083**	-8.469**	-1.569**	-0.027	-7.84**	-1.268**	-722.361**
9	R 9	1.278**	-4.469**	0.181	-0.444	4.57**	0.241	-107.472**
10	R 10	-1.694**	-25.052**	-0.542	-0.335	3.22**	0.198	-95.019**
11	R 11	-1.083**	1.281**	-0.153	-0.027	3.74**	-0.024	-285.292**
12	R 12	1.500**	28.240**	0.514	0.806	-4.81**	-0.415	487.783**
SE (gi) testers		0.424	13.037	0.229	0.064	0.234	0.251	95.861
SE(gi – gj)		1.200	36.875	0.648	0.181	0.659	0.710	271.135
Lines								
1	CMS 4A	2.833**	82.906**	-0.653	0.973	8.79**	0.332	-413.094**
2	CMS 6A	3.167**	-8.469**	1.847**	-1.277**	-0.52	0.559	2045.131**
3	CMS 14A	-0.917	-2.469**	-0.903	-0.702	-8.27**	-1.228**	-695.494**
4	CMS 15A	-3.333**	-9.469**	1.597**	0.223	3.67**	0.640	978.405**
SE(gi) lines		0.812	24.964	0.439	0.123	0.345	0.481	183.559
SE(gi – gj)		0.693	21.290	0.374	0.105	0.298	0.410	156.540

M*, ** Significant at 5% and 1% probability levels, respectively.

Table 6: Estimates of specific combining ability (SCA) effects of crosses for 7 characters in rice

S. No.	Crosses	Days to 50% flowering	Plant height	Productive tillers per hill	Panicle length	Number of grains per panicle	1000-Grain wt.	Grain yield per plant
1	CMS 4A × R1	-0.028	-83.656**	-0.181	0.194	38.56**	2.183**	-3105.778**
2	CMS 6A × R1	-2.056**	-83.073**	1.542**	0.085	-14.74**	-0.073	1059.469**
3	CMS 14A × R1	2.333**	-81.406**	0.153	-0.223	-23.82**	1.882**	2955.941**
4	CMS 15A × R1	-0.250	248.135**	-1.514**	-0.056	-3.83**	0.373	-909.633**
5	CMS 4A × R2	-0.361	9.719**	1.319**	-0.556	-0.33	1.297**	350.697**
6	CMS 6A × R2	-0.389	3.302**	-1.958**	1.335**	4.16**	1.567**	-247.257**
7	CMS 14A × R2	1.333**	5.969**	1.347**	2.027**	5.50**	1.422**	1155.215**
8	CMS 15A × R2	-0.583	-18.990**	1.986**	-2.806**	-0.09	4.287**	-1258.659**
9	CMS 4A × R3	-1.278**	5.719**	-0.931	0.869	-5.41**	0.011	-37.378**
10	CMS 6A × R3	1.694**	15.302**	1.792**	-1.940**	-25.75**	-0.680	-886.632**
11	CMS 14A × R3	-0.917	3.969**	-3.597**	0.452	10.06**	-0.231	-198.359**
12	CMS 15A × R3	0.500	-24.990**	2.736**	0.619	15.69**	0.900	122.367**
13	CMS 4A × R4	2.472**	8.719**	-2.431**	-1.056**	12.56**	-0.791	-756.977**
14	CMS 6A × R4	-0.556	5.302**	1.292**	1.835**	-14.71**	-0.148	148.769**
15	CMS 14A × R4	-1.167**	8.969**	1.903**	1.527**	2.15**	0.507	919.441**
16	CMS 15A × R4	-0.750	-22.990**	-0.764	2.306**	-44.09**	0.432	-311.233**
17	CMS 4A × R5	-0.778	10.969**	0.069	1.694**	23.44**	-0.108	-324.502**
18	CMS 6A × R5	-1.806**	3.552**	-0.208	-1.415**	20.64**	-0.332	-255.490**
19	CMS 14A × R5	3.583**	8.219**	0.403	0.277	-17.57**	-0.509	-113.717**
20	CMS 15A × R5	-1.000	-22.740**	-0.264	-0.556	27.87**	0.948	1693.708**

21	CMS 4A × R6	4.056**	7.469**	0.569	2.194**	-10.30**	-0.041	566.472**
22	CMS 6A × R6	2.028**	4.052**	-0.708	-0.915	-9.80**	-0.698	-245.881**
23	CMS 14A × R6	-0.917	8.719**	-1.097**	-1.223**	-11.79**	0.324	-53.808**
24	CMS 15A × R6	-5.167**	-20.240**	1.236**	-0.056	21.59**	0.415	-266.783**
25	CMS 4A × R7	4.222**	9.219**	-0.181	-0.806	7.38**	-0.974	-1296.328**
26	CMS 6A × R7	-0.806	0.802	0.542	0.085	-15.22**	0.035	721.719**
27	CMS 14A × R7	-4.417**	11.469**	0.153	0.777	7.84**	0.524	1551.491**
28	CMS 15A × R7	1.000	-21.490**	-0.514	-0.056	-9.69**	0.415	-976.883**
29	CMS 4A × R8	-1.528**	7.469**	0.069	-2.306**	10.26**	-1.824**	-240.228**
30	CMS 6A × R8	4.444**	15.052**	-1.208**	2.415**	-0.57	1.085**	267.618**
31	CMS 14A × R8	-2.167**	3.719**	1.403**	0.277	33.66**	-0.593	-2257.309**
32	CMS 15A × R8	-0.750	-26.240**	-0.264	4.444**	-15.81**	1.332**	289.917**
33	CMS 4A × R9	-5.528**	6.219**	-2.181**	-1.306**	-17.85**	0.034	-815.078**
34	CMS 6A × R9	-2.556**	6.802**	1.542**	1.585**	-13.37**	-0.357	655.068**
35	CMS 14A × R9	1.833**	9.469**	1.153**	-0.723	4.11**	0.032	499.941**
36	CMS 15A × R9	6.250**	-22.490**	-0.514	0.444	9.26**	0.290	-339.933**
37	CMS 4A × R10	1.556**	5.719**	2.819**	1.056**	6.21**	1.976**	4650.147**
38	CMS 6A × R10	-0.806	16.302**	-1.458**	-0.165	1.46**	0.018	-1159.540**
39	CMS 14A × R10	0.917	2.969**	0.153	-0.473	4.75**	-1.126**	-1659.267**
40	CMS 15A × R10	-1.667	-24.880**	-1.514**	1.694**	-5.55**	-0.868	-1831.342**
41	CMS 4A × R11	-0.528	6.719**	0.319	-0.056	-0.39	0.519	2105.363**
42	CMS 6A × R11	2.111**	5.302**	-1.958**	1.835**	5.95**	0.355	-561.891**
43	CMS 14A × R11	-0.500	8.969**	0.653	-0.473	3.04**	-1.849**	-3190.917**
44	CMS 15A × R11	-1.083	-20.990**	0.986	-1.306**	-9.96**	0.975	647.442**
45	CMS 4A × R12	-2.278**	5.719**	0.736	2.194**	6.92**	2.084**	1103.589**
46	CMS 6A × R12	-1.306**	7.302**	0.792	0.085	10.83**	-0.773	-835.964**
47	CMS 14A × R12	0.083	8.969**	0.069	-2.223**	-0.93	-0.384	391.342**
48	CMS 15A × R12	3.500**	-21.990**	-1.597**	-0.056	-9.91**	-0.927	-658.966**
	SE (S_{ij})	1.407	43.239	0.760	0.212	0.649	0.832	317.934
	SE ($S_{ij} – S_{kl}$)	2.498	76.761	1.349	0.377	0.982	1.477	564.412

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

Table 7: Most promising cross combinations for different characters along with their mean performance and GCA effects of parents

Characters	Crosses with significant effects	Mean performance of crosses	gca effects of parents
Days to 50% flowering	CMS 4A x R9	-5.53	H x H
	CMS 15A x R6	-5.17	H x H
	CMS 14A x R7	-4.42	A x L
	CMS 6A x R9	-2.56	H x H
	CMS 4A x R12	-2.28	H x H
Plant height	CMS 4A x R1	-83.66	H x A
	CMS 6A x R1	-83.07	L x L
	CMS 14A x R1	-81.41	L x L
	CMS 15A x R8	-26.24	L x L
	CMS 15A x R3	-24.99	L x L
Productive tillers per hill	CMS 4A x R10	2.82	A x A
	CMS 15Ax R3	2.74	H x L
	CMS 15A x R2	1.99	H x L
	CMS 14A x R4	1.90	A x H
	CMS 6A x R1	1.54	H x A
Panicle length	CMS 15A x R8	4.44	A x A
	CMS 6A x R8	2.42	L x A
	CMS 15A x R4	2.31	A x H
	CMS 4A x R6	2.19	A x A
	CMS 14A x R2	2.03	A x A
Number of grains per panicle	CMS 4A x R1	38.56	H x H
	CMS 14A x R8	33.66	L x L
	CMS 15A x R5	27.87	H x L
	CMS 4A x R5	23.44	H x H
	CMS 15 A x R6	21.59	H x H
1000- grain weight	CMS 15A x R2	4.29	A x A
	CMS 4A x R1	2.18	A x A
	CMS 4A x R12	2.08	A x A
	CMS 4A x R10	1.98	A x A
	CMS 14A x R1	1.88	L x A
Grain yield per plant	CMS 4A x R10	4650.15	L x L
	CMS 14A x R1	2955.94	L x H
	CMS 4A x R11	2105.36	L x L
	CMS 15A x R5	1693.71	H x H
	CMS 14A x R7	1551.49	L x H

H = High (significant and positive), **L=** Low (significant and negative) **A=** Average (non-significant)

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