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Estimation of specific combining ability in Indian mustard (*Brassica juncea* L)

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Abstract
The specific combining ability analysis (SCA) of 10 parents and their-45F_1's and 45 F_2S generated through Diallel system of mating revealed that significant differences existed for specific combining ability for all the characters. SCA variances were important for all the characters indicating the presence of both additive and non-additive gene effects in controlling the expression of various characters. Cross Vardan x RH-819 (F_1) and Krishna x RH-30 (F_2) expressed higher SCA effect for higher seed yield. Cross RH-819 x RH-9304 and Rohini x Vaibhav expressed high SCA effect for oil content in both the generation, respectively. Additive gene action along with partial dominance was observed in seed yield, oil content and test weight. Varuna x RH-9801 and Vaibhav x RH-30 and Rohini x RH-9304 and Varuna x RH-9304 also exhibited desirable specific combining ability effect for earliness and late flowering. RH-9304 x RH-30 and Rohini x RGN-19 exhibited superior specific combining ability effect for length of main raceme and number of siliqua on main raceme in F_1 and F_2 generation. No. of primary and secondary branches per plant cross Vaibhav x RH-819 and Rohini x RGN-19 expressed high SCA effect in both the generation. Most of the cross involving high×low specific combining parent, exhibited high SCA effect for various traits.

Keywords: *Brassica juncea,* specific combining ability and diallel

Introduction
Indian mustard belongs to family Brassicacae and genus *Brassica.* Indian mustard [*Brassica juncea* (L) Czern & Coss] is a natural amphidiploids (2n =36) of *Brassica rapa* (2n = 20) and *Brassica nigra* (2n = 16). Mustard is largely self pollinated but certain amount (2 - 15%) of cross pollination may take place due to honeybees. It contributes more than 13 per cent to the global production of edible oil. In India the area of rape and mustard 5.92Mha, Production 6.78MT and yield 1145kg/ha in 2011-12. Seed contain 38 to 40 per cent oil and is mainly utilize for human consumption throughout Northern India for cooking as well as frying purpose. A high yielding genotype may/may not transmit its superiority to its progeny. For International acceptance, erucic acid content should be <2%.Hence, in order to develop high yielding varieties, it would be desirable to identify parents with good combining ability for different traits and the nature of gene action governing yield and their component traits, which could be of great help in selecting parents for the hybridization programme GCA and SCA variances were significant in all characters. Larik *et al.,* (1999) [3] and Nasrin *et al.,* (2011) [1] reported that GCA effect was significant for plant height days to 50% flowering, days to maturity and thousand seed weight and significant SCA was also observed for the entire trait except days to flowering and number of seeds per siliqua. Therefore, this paper deals with estimation of relative importance of GCA and SCA variances and heterosis for yield and its components Kumar *et al.,* (2013) [5] observed that economic heterosis on the basis of per se performance and SCA effects in F_1 crosses. Out of 45 crosses only 4 crosses exhibited desirable SCA effects namely Varuna x Kranti, Varuna x NDR-8501, Pusa Bold x KRV-Tall and Kranti x Rohini had high economic heterosis (58.83, 54.84, 52.56 and 37.67% respectively. Kumar *et al.,* (2013) [5] reported that the ratio of GCA and SCA variances were below unity. Varuna and RK03-2 is the best parent for almost all traits as their GCA and per se performances are highest. Varuna X RK 304 and Varuna X RK301 showed high per se performance as well as SCA effects. Therefore, keeping this in view the research to examine the best parent and best crosses can be used in hybridization and heterosis breeding respectively.

Materials and Methods

Ten parents viz Varuna, Rohini, Krishna, Vaibhav, Vardan, Maya, NDRE-4, RH-9304, RH-819, and Pusa Mahak were crossed in half diallele fashion to produce 45 F_1^s. Ten parents and their 45F_1^s were grown in a randomized block design with three replication. Each parent and F_1^s. were grow in single row of 5m length with row to row and plant to plant distance of 45 and 15cm respectively in each replication during rabi 2010-2011 at the experimental research farm of C.S. Azad University of Agriculture and Technology, Kanpur. Recommended cultural practices were adopted in order to raise a healthy crop. A sample of five representative plant were taken from each plot for recording data on plant height number of primary branches, number of secondary branches, number of siliqua on main raceme, seed yield, test weight and oil content in each replication while data on days 50% flowering, days to maturity were recorded on plot basis. Mean values of sample for various traits were subjected to combining ability analysis method II model I of Griffing (1956). The mathematical model for the combining ability analysis is assumed to be:

Yijkl = u + gi + gj + sij + 1/bc Σi Σeijk (i, j) = 1, 2, 3… n;
k = 1, 2, 3…b;
l = 1, 2, 3… c)

Where,
Yijkl= mean of i x jth genotype in kth replication
u= the population mean
gi= the general combining ability (gca) effect of ith parent
gj= the gca effect of jth parent
sij = the specific combining ability (gca) effect for the cross between ith, jth parent such that sij = sji
Σi Σeijkl= the environmental effect associated with the ijklth individual observation on ith individual in the kth block with ith as female parent and jth as male parent.

Statistical analysis was based on the method analysis of variance as suggested by Panse and Sukhatme (1967) and the standard error difference was computed by at 5% and 1% level of significance.

Result and Discussion

Statistically significant differences among the crosses with respect to specific combining ability effect were significant for all the attributes are presented in Table 2. A significant difference was noted in days to flowering. The cross Varuna x RH-9801 followed by Rohini x RH-819, Vardan x RH-30, RH-9304 x RH-9801 and Rohini x Vardan in F_1 and cross Vaibhav x RH-30 followed by Krishna x RGN-19, Rohini x Krishna, Vardan x RH-30 and Rohini x Vardan in F_2 expressed higher SCA effects for early flowering, while the cross Rohini x RH-9304 in F_1 and Varuna x RH-9304 in F_2 showed late flowering. The cross varuna x RH-9304 followed by Varuna x RH-9801, Rohini x RH-9304, RGN-19 x RH-9801 and Vardan x RH-9304 in F_1 and cross Varuna x RH-9304, RH-9801x RH-30, Varuna x RGN-19, Vardan x Krishna and Varuna x Rohini in F_2 showed high SCA effect for short plant. However, cross Varuna x RGN-19 followed by RH-819x Krishna, Rohini x RH-9801, Vaibhav x RH-819 and Krishna x RGN-19 in F_1 and crosses Rohini x RGN-19, RH-9304x RH-30, Rohini x RH-9801 in F_2 expressed high SCA effect for longer plant. For the number of primary branches per plant a significant differences was recorded in crosses RH-9304 xRH-30, Vardan x Krishna, Vardan x Rohini, Varuna x Rohini, Vaibhav x RH-9801, Vaibhav x Krishna and RH-819 x RH-9801 in F_1 and cross Rohini x RGN-19 followed by RH-9304 x RH-30, Rohini x RH-9801 and Vardan x RGN-19 in F_2 expressed high SCA effect. A significant difference was noted for number of secondary branches per plant in both the generation. The cross Vaibhav x RH-819, RH-9304x RH-30, Rohini x RH-9801, Vaibhav x RH-9801 in F_1 and the cross Rohini x RGN-19, RH-9304 x RH-30, Vardan x RH-9304, Vardan x RGN-19 in F_2 expressed high SCA effect.

Significant differences were noted for the length of main receme in relation to SCA effect. The crosses RH-9304 x RH-30, Vaibhav x RGN-19, Vaibhav x Krishna, Varuna x RH-9801 in F_1 and the cross Rohini x RGN-19 followed by RH-9304 x RH-30, Vaibhav x Vardan, Vardan x Krishna, and Vardan x RH-9304 in F_2 were recorded for expression of high SCA effect. The cross RH-9304 x RH-30 followed by Vardan x RGN-19, Vaibhav x RGN-19, Varuna x RH-9801 and Vaibhav x Krishna in F_1 and the cross Rohini x RGN-19 followed by RH-9304 x RH-30, Vaibhav x Vardan, Vaibhav x RH-819 and Vardan x Krishna in F_2 expressed higher SCA effect for number of siliqua on main raceme. A significant difference was noted in days to maturity. The crosses Vaibhav x RH-30, RH-819 x RH-9304, Varuna x RH-9801, Krishna x RH-9304 and Rhini x Vaibhav in F_1 and crosses Krishna x RH-9801, Rohini x Vaibhav, Vardan x Krishna, Vardan x RH-9801 and Varuna x Vaibhav in F_2 were recorded for expression of high SCA effect. The crosses Vaibhav x Krishna, Varuna x RGN-19, RH-819 x RH-30, RH-819 x RH-9304 and Vauna x Vaibhav in F_1 and cross Rohini x RH-9801, RH-9304 x RGN-19, Rohini x Vaibhav, Varuna x Vardan and Vaibhav x RH-9304 in F_2 were reported for high SCA effect in relation to number of seeds per siliqua. Significant SCA effects were recorded for test weight in both the generation. The cross Varuna x Rohini in F_1 and cross Rohini x RH-819 in F_2 were recorded high SCA effect for test weight. The cross RH-819 x RH-9304 followed by RGN-19 x RH-9801,RH-819 x RH-30, Vaibhav x Krishna and Varuna x Rohini in F_1 and cross Rohini x Vaibhav followed by Vaibhav x RH-30, RH-819 x RGN-19, RH-9304 x RGN-19 and Rohini x RGN-19 in F_2 expressed high SCA effect for oil content. The cross Vardan x RH-819 followed by Vaibhav x Krishna, Vardan x RH-30, Varuna x RGN-19 and Vauna x RH-9801 in F_1 and cross Krishna x RH-30 followed by Rohini x Rh-9801, Vardan x Krishna, Varuna x RGN-19 and Rohini x RGN-19 in F_2 expressed high SCA effect for higher yield per plant in both the generation.

In general SCA is associated with interaction effects which may be due to dominance and epistatic component of variation that are non-fixable in nature. Among the 45 cross combination and their 45 F_2 population none of the hybrid/ cross combinations, exhibited consistent high SCA effects for all the character. Kumar *et al.*, (2013) [5] reported similar result. Out of 45 hybrids and 45 their sergeants, 21 and 17 for days to flowering, 20 and 19 for plant height, 5 and 4 for number of primary branches, 11 and 13 for number of secondary branches, 30 and 26 for length of main raceme and 12 and 8 for days to maturity, 9 and 8 for number of seed per siliqua, 12 and 9 for test weight, 18 and 17 for oil content and 18 and 20 cross combination for total yield per plant were found to be desirable and significant specific combination in both the generation. The superior F_1^s involving high and low performing parents and exhibiting high SCA effects, beside being promising F_1 hybrids are expected to segregate for desirable transgrassive as the desirable additive gene effects of the parent and the complementary epistatic effects of the cross are coupled in the direction to maximize the character under study. The SCA effects play most important role for the improvement of the cross pollinated crops where commercial exploitation of heterosis is feasible. The choice of breeding method primarily depends upon the nature and magnitude of gene action. When additive affects forms the principal factors for genetic variance use pedigree method. The different type of gene effects in a population can be exploited by adopting a suitable mode of recurrent selection based of selected genotypes in each cycle. Similar finding were also reported by Nasrin *et al.*, (2011) [1] in wheat crops.

The parent analysis showed that vardan, RH-819, Varuna and RGN-19 were promising parents for such a breeding strategy. These parents may directly be exploited for maximizing the yield potential involving the superior F_1 hybrid in mustard. This indicated the role of non-additive gene action in the inheritance of these traits. This is in agreement with the studies of Rao and Gulati (2001) [6].

Table 1 (a): Combined analysis of variance for parents, F_1's parents Vs F_1's in diallele mating design for yield and yield attributing characters of mustard

Source of Variation	d.f.	Days to flowering	Plant Height (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	Length of main raceme	No. of siliqua on main raceme	Days to maturity	No. of seeds /siliqua	Test weight	Oil content (%)	Yield/Plant (g)
Replications	2	0.245	2.547	1.661	3.161	0.789	0.344	0.677	0.217	0.071	0.141	0.297
Treatments	54	14.745**	356.585**	0.462	2.774**	174.562**	160.031**	8.260**	2.293**	0.362	8.290**	38.209**
Parents	9	12.658**	378.499**	0.540	3.592**	190.579**	138.691**	6.642**	2.605**	0.655	4.155**	20.302**
F_1'S	44	15.488**	399.370**	0.456	2.630**	149.184**	141.199**	8.778**	2.196**	0.231	8.425**	41.472**
P vsF_1'S	1	0.752**	917.198**	1.263**	1.738**	1147.049**	1180.713**	0.083	3.781**	3.490**	39.559**	55.829**
Error	108	0.264	0.785	0.168	0.251	0.268	0.823	0.848	0.331	0.012	0.104	0.215

*Significant at 5% level,
**Significant at 1% level

Table 1 (b): Combined analysis of variance for parents, F_2's parents Vs F_2's in diallele mating design for yield and yield attributing characters of mustard

Source of Variation	d.f.	Days to flowering	Plant Height (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	Length of main raceme	No. of siliqua on main raceme	Days to maturity	No. of seeds /siliqua	Test weight	Oil content (%)	Yield/Plant (g)
Replications	2	0.681	0.188	0.411	0.853	0.176	1.282	6.962	1.825	0.014	0.548	0.284
Treatments	54	10.495**	600.246**	0.603**	1.734**	197.748**	204.003**	5.003**	3.218**	0.562	6.072**	24.876**
Parents	9	12.658**	378.499**	0.540*	3.592**	190.579**	138.691**	6.642**	2.605**	0.655**	4.155**	20.302**
F_2'S	44	10.265**	547.396**	0.609**	1.328*	158.649**	191.613**	4.781**	3.084**	0.245**	6.468**	25.239**
P vsF_2'S	1	1.015**	4921.69**	0.867**	2.849**	1982.582**	1337.48**	0.376	14.652**	2.844**	5.824**	50.080**
Error	108	0.279	0.303	0.241	0.249	0.428	0.821	2.874	0.279	0.036	0.118	0.315

*Significant at 5% level,
**Significant at 1% level

Table 2: Estimation of Specific combinining ability effect on growth, yield and yield attributes of in Indian mustard

S. No	Hybrid/ cross combination	Days to flowering		Plant height		No. of primary branches /plant		No. of Secondary branches /plant		Length of main raceme		No. of siliqua on main raceme		Days to maturity		No. of seeds /siliqua		Test weight		Oil content (%)		Yield /plant (g)	
		F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
1	Varunax Rohini	-0.60*	-0.24	5.77**	-9.21**	-0.23	-0.53*	-0.05	-0.13	-6.38**	-6.80**	-3.80**	-2.48**	-0.91	-1.77	-0.13	-1.11**	0.73*	0.00	2.14**	0.01	-3.86**	-3.80**
2	Varunax Vaibhav	-0.48*	1.83**	-2.48**	-6.51**	-0.27	-0.22	-0.11	1.14**	1.77**	5.96**	-2.50**	0.07	0.01	-2.04*	1.01*	0.44	-0.43*	-0.02	1.90**	-0.10	0.91*	2.24**
3	Varunax Vardan	0.23*	-2.91**	0.56	10.94**	0.01	0.14	0.49	0.37	0.12	1.05*	-3.58**	-3.91**	1.37*	1.99*	0.12	0.93*	-0.05	0.01	-0.65*	0.28	-4.18**	-4.96**
4	Varunax RH819	0.99*	3.29**	-1.55*	3.99**	0.05	-0.36	-0.12	-0.40	-2.06**	-16.69**	0.28	-18.61**	-2.26	3.00*	-1.14*	0.14	-0.41*	0.44**	-2.09**	-0.32	-6.70**	3.47**
5	Varunax Krishna	0.89*	0.52	-1.12*	-2.78**	0.07	0.24	-0.51	-0.71	6.05**	-0.74*	6.23**	-2.30**	-0.47	-1.20	0.92	-0.80*	-0.42*	0.14	0.69**	-0.44**	1.51**	-1.91**
6	Varunax RH-9304	0.52*	3.34**	-24.29**	-24.29**	0.38	0.38	-0.47	-0.47	-16.52**	-16.52**	-12.96**	-12.69**	0.56	0.56	1.03*	-1.03*	-0.52*	-0.52**	-1.60**	-1.60**	1.79**	1.79**
7	Varunax RGN-19	1.37**	1.54**	20.78**	-12.89**	0.51*	0.25	-0.91*	0.16	0.77*	1.66**	-4.01**	-0.56	0.35	2.65*	2.06**	-0.11	0.15*	-0.21*	1.86**	-2.19**	5.52**	4.49**
8	Varunax RH-9801	-5.33**	2.87**	-16.22**	3.43**	-1.16**	-0.56*	-0.34	-0.96*	10.47**	-0.44	9.72**	-4.07**	-2.49**	2.62*	-0.29	-1.87**	-0.18*	-0.30*	2.00**	-1.77**	4.90**	-3.43**
9	VarunaxRH-30	1.81**	-1.86**	2.21**	-8.26**	-0.09	-0.51*	0.05	-1.20**	1.65**	6.26	4.04**	6.59**	2.43**	-1.23	0.04	0.14	0.16*	-0.19	-1.53**	1.57**	-3.14**	-3.84**
10	Rohinix Vaibhav	0.140*	-1.83**	-2.08**	-1.35**	-0.37	0.33	-0.14	-0.43	-6.69**	0.74*	6.63**	-0.25	-1.82*	-2.47*	-0.54	1.04	0.42*	0.35*	1.82**	2.75**	0.94*	-2.97**
11	Rohinix Vardan	-3.02**	-2.95**	8.46**	-6.51**	-0.26	-0.22	-0.15	1.14**	2.10**	5.96**	-4.32**	0.07	-0.97*	-2.04*	0.90*	0.44	-0.01	-0.02	-0.49*	-0.10	-0.37	2.24**
12	RohinixRH-819	-4.56**	1.65**	3.47**	5.22**	-0.58*	-0.17	-0.12	0.08*	9.28**	-7.41**	-5.78**	-3.57**	-1.74*	-0.11	0.58	0.62**	0.34*	0.91**	0.97**	-1.20**	0.26	-0.65*
13	RohinixKrishna	-2.85**	-3.11**	-2.46**	0.84*	0.20	-0.01	0.42	0.20	4.73**	2.31**	5.03**	2.86**	-1.01*	-0.95	-0.73*	-0.32	-0.22*	-0.06	-1.73**	-0.40*	-0.73	0.58*
14	Rohinix RH-9304	3.34**	1.37**	-12.89**	1.49**	0.25	-0.18	0.16	-0.02	1.66**	0.11	-0.56	-1.21*	2.65**	1.26	-0.11	0.23	-0.21*	-0.20*	-2.19**	1.46**	4.49**	-0.70*
15	Rohinix RGN-19	0.21*	0.21	-2.40**	37.12**	-0.05	0.85*	0.82*	1.43**	-1.72**	14.76**	-4.37**	16.40**	-0.95	-0.17	0.32	0.23	-0.20*	0.03	0.50*	2.08**	-0.43	4.31**
16	Rohinix RH-981	1.86**	-2.07*	14.11**	20.78**	0.17	0.51*	1.42**	-0.91*	9.18**	0.77*	6.69**	-4.01**	1.39*	0.35	0.46	2.06**	-0.19*	0.15	-0.97**	1.86**	2.12**	5.52**
17	RohinixRH-30	1.10**	2.96**	-2.83**	-2.40**	-0.12	-0.05	-0.72*	0.82**	-6.61**	-1.72**	2.41**	-4.37**	0.80	-0.95	0.72*	0.32	0.07	-0.20*	1.85**	-0.50*	-0.32	-0.43
18	Vaibhavx Vardan	0.97*	-1.38**	2.08**	-6.91**	-0.37	0.04	0.23	0.21	-3.78**	11.30**	-5.19**	9.96**	-0.04	0.21	-0.46	0.45	-0.13*	-0.32*	-1.06**	-0.67*	-3.71**	-0.21
19	Vaibhavx RH-819	-1.63**	-2.91**	11.70**	-2.01**	0.15	0.39	1.50**	0.13	0.90*	7.86**	5.84**	9.82**	-0.91	-0.54	-0.32	0.44	0.17*	0.35*	-2.22**	1.98**	0.49*	1.14**
20	Vaibhavx Krishna	-1.34**	1.65**	-7.23**	-7.82**	0.47*	0.54*	-1.23**	-0.11	10.63**	2.44**	9.59**	-2.50**	0.44	0.02	2.14**	-0.50	-0.08	-0.26*	2.48**	-0.02	6.55**	-4.46**
21	Vaibhavx RH-9804	1.54**	0.54	3.43**	10.94**	-0.56*	0.14	-0.96*	0.37	-0.44	1.05*	-4.07**	-3.91**	2.62**	1.99*	-1.87**	0.93*	-0.30*	-0.01	-1.17**	0.28	-3.43**	-4.96**
22	Vaibhavx RGN-19	-2.07**	-0.56*	-6.91**	0.84*	0.04	-0.01	0.21	0.20	11.30	2.31**	9.76**	2.86**	0.21	0.95	0.45	-0.32	-0.32*	0.06	-0.67**	-0.40*	-0.21	-0.58*
23	Vaibhavx RH-9801	1.08**	-.36	-7.40**	-3.24**	0.50*	-0.04	1.34**	-0.27	-9.47**	-7.99**	-5.84**	-3.94**	-1.41*	0.08	-0.06	-0.72*	-0.22*	0.21*	0.01	-2.79**	0.50*	-0.44
24	Vaibhavx RH-30	1.81**	-5.33**	3.03**	-8.86**	0.27	-0.39	0.73*	-1.10*	3.68**	-14.34**	3.56**	6.94**	-2.84**	0.29	0.76*	-0.34	-0.37*	-0.33*	-0.50*	2.64**	-1.20**	2.08**
25	Vardanx RH-819	-0.46*	1.86**	4.81**	1.91**	-0.41	-0.01	1.22*	0.93*	3.51**	6.35**	7.56**	-6.70**	1.04*	-0.57	0.16	-0.72*	-0.08	0.26*	1.49**	-0.78**	11.23**	2.76**
26	Vardanx Krishna	2.81**	1.08**	6.21**	-10.22	0.68*	-0.16	1.26**	-0.34	-4.67**	10.47**	-0.59	9.72**	3.20**	-2.44*	-1.22**	-0.29	-0.08	-0.18	-2.06**	2.00**	-0.86*	4.90**
27	Vardanx RH-9304	2.87**	-2.81**	-8.26**	14.11**	-0.51*	0.17	-1.20**	1.42**	6.26**	9.18**	6.59**	6.69**	-1.23*	1.39*	0.14	-0.46	0.19*	-0.19	1.57**	-0.97**	-3.84**	2.12**
28	Vardanx RGN-19	2.96**	2.12**	-2.61**	-7.40**	0.39	0.50	0.13	1.34**	7.86**	-9.47**	9.82**	-5.84**	-0.54	-1.41	-0.44	-0.06	0.35*	-0.22*	1.98**	0.01	1.14**	-0.50
29	Vardanx RH-9801	-2.86**	3.29**	4.91**	4.91**	-0.62*	-0.62*	-1.93**	-1.93**	6.55**	6.55**	1.10*	1.10*	-1.19*	-2.19*	-0.39	-0.39	0.02	0.02	1.45**	1.45**	0.28	0.28
30	Vardanx RH-30	-3.38**	-3.11**	0.24	8.89**	0.39	0.42	0.24	0.20	2.17**	3.63**	8.35**	7.03**	0.21	2.60*	-0.23	-0.75*	-0.07	-0.27*	-1.55**	-0.08	5.76**	-2.94**
31	RH-819x Krishna	1.24**	-0.56*	17.39**	3.99**	-0.15	-0.36	-0.07	-0.40	7.28**	-16.69**	9.44**	-18.61**	-0.37	3.00*	0.39	0.14	-0.25*	0.44**	1.20**	-0.39	2.29**	3.47**
32	RH-819x RH-9304	-1.86**	1.31**	-1.35*	1.49**	0.33	-0.18	0.43	-0.02	0.74*	0.11	-0.25	-1.21**	-2.47**	1.26	1.04*	0.23	-0.35*	-0.20*	2.75**	1.46**	-2.97**	-0.70*
33	RH-819x RGN-19	-1.38**	0.84*	-7.82**	-8.86**	-0.54*	-0.39	-0.11	-1.10**	2.44**	-14.37**	-2.50**	6.94**	0.02	0.29	-0.50	-0.34	-0.26*	-0.33*	-0.02	2.64**	-4.46**	2.08**
34	RH-819x RH-9801	2.12**	1.81**	8.89**	-3.08**	0.42	0.21	0.20	0.14	3.63**	4.16**	7.03**	-3.26**	2.60**	-1.97*	-0.75*	0.50	-0.27*	0.54**	-0.08	-2.33**	-2.94**	-2.21**
35	RH-819x RH-30	-0.54*	1.10**	-2.11**	-0.74*	-0.44*	0.21	-1.05**	0.53*	3.45**	2.28**	2.92**	0.69	-0.72	1.44	1.41**	-0.01	-0.30*	-0.14	2.51**	-1.52**	4.9**	-4.28**
36	Krishnax RH-9304	-1.83**	1.81**	-6.51**	2.21**	-0.22	-0.09	1.14**	0.05	5.96**	1.65**	0.07	4.04**	-2.04**	2.43*	0.44	0.04	-0.02	0.16	-0.10	-1.33**	2.24**	-3.14**
37	Krishnax RGN-19	2.91**	-3.38**	10.94**	-2.83**	0.14	-0.12	0.37	-0.72*	1.05**	-4.61**	-3.91**	2.41**	1.99**	0.80	0.93*	0.72*	-0.01	0.07	0.28	1.85**	-4.96**	-0.32
38	Krishnax RH-9801	3.29**	-0.54	3.99**	3.03**	0.36	0.27	-0.40	0.73*	-16.69**	3.68**	-18.61**	3.56**	3.00**	-2.84*	0.14	0.76*	0.44*	-0.37*	0.32	-0.50*	3.47**	-1.20**
39	Krishnax RH-30	0.17*	0.17	-2.78**	0.24	0.24	0.39	-0.71	0.24	0.74*	2.17*	-2.30**	8.35**	-1.20*	0.21	-0.80*	-0.23	0.14*	-0.07	-0.44*	-1.55**	-1.91**	5.76**
40	RH-9304x RGN-19	1.65**	2.78**	0.84	-2.11**	-0.01	-0.44	0.20	-1.05**	2.31**	-3.45**	2.86**	2.92**	0.95	-0.72	-0.39	1.41**	-0.06	-0.32	-0.40*	2.51**	-0.58*	4.09**
41	RH-9304x RH-9801	-3.11**	-0.36	1.49**	-2.78**	-0.18	0.24	-0.02	-0.71*	0.11	-0.74**	-1.21*	-2.30**	1.26*	-1.20	0.23	-0.80*	-0.20	0.14	1.46**	-0.44*	-0.70*	-1.91**
42	RH-9304xRH-30	2.78**	0.84*	1.49**	37.12**	0.85**	0.85*	1.43**	1.43**	14.74**	14.76**	16.40**	16.40**	-0.17	-0.17	0.23	0.23	0.03	0.03	2.08**	2.05**	4.31**	4.31**
43	RGN19x RH-9801	-0.56*	-2.11**	-8.86**	1.91*	-0.39	-0.01	-1.10**	0.93*	-14.37*	6.35**	6.94**	-6.70**	-0.29	-0.57	-0.34	-0.72*	-0.33*	0.26*	2.64**	-0.78**	2.08**	2.76**
44	RGN19x RH-30	-0.36*	-0.54	1.91**	-0.74*	-0.01	0.21	0.93*	0.53*	6.35**	2.28**	-6.70**	0.69	-0.57	1.44	-0.72*	-0.01	0.26*	-0.14	-0.78**	-1.52**	2.76**	-4.28**
45	RH-9801x RH-30	0.84*	1.89**	0.74	-18.2**	0.21	-0.65*	0.53*	-0.71*	2.28**	-11.04**	0.69	-14.69	1.44	0.31	-0.01	0.04	-0.14*	0.12	-1.52**	-0.86**	-4.28**	-3.03**
	SE(sij)±	0.27	0.28	0.47	0.29	0.22	0.26	0.27	0.26	0.28	0.35	0.48	0.48	0.49	0.90	0.31	0.28	0.06	0.10	0.17	0.18	0.25	0.29
	SE (sij-sik)±	0.39	0.41	0.68	0.42	0.32	0.39	0.93	0.39	0.40	0.51	0.71	0.71	0.72	1.39	0.45	0.41	0.08	0.15	0.25	0.27	0.36	0.37

*Significant at 5% level,
**Significant at 1% level

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