



COMBINING ABILITY FOR YEILD AND YEILD ATTRIBUTES IN INDIAN MUSTARD (*BRASSICA JUNCEA* L.)

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ABSTRACT

The combining ability analysis of 10 parents and their-45F₁'s and 45 F₂S generated through Diallel system of mating revealed that significant differences existed for general combining ability (GCA) for all the characters. GCA 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. Parent Rohini, Varuna and RH-9801 were the good general combiners for seed yield and oil content. Additive gene action along with partial dominance was observed in oil content and 1000-seed weight. RH-819, RH-9304 and Vaibhav also exhibited desirable general combining ability effect for earliness and longer plant height. Varieties RGN-19, RH-9304 showed better performance for early flowering, No. of secondary branches per plant and other yield attributing traits in both the generation.

Key Words : *Brassica Juncea*, General combining ability, Diallel

The Brassicaceae family consists of many important field crops and vegetables such as mustard. Mustard rank third in the world and most important vegetable oil source with an annual growth rate exceeding of palm. Mustard is the world's second leading source of protein meals. The main mustard producing regions of the world are China, Canada, India and Northern Europe. Worldwide production of mustard has increased six fold between 1975 and 2007 by the aim of conventional and modern plant breeding approaches. World production is expected to trend further upward over between 2005 and 2015 (UN Food & Agriculture Organization (FAO). Indian mustard (*Brassica juncea*

L. (Czern and coss)) is an important oil seed crop in India. It has 38 to 42% oil and 24% protein. Diallel analysis provides a mating design whereby the selected parents are crossed in all possible combinations. The mean values are used for predicting combining ability of the parents (GCA) and hybrids (SCA) to enlighten the nature of gene action involved in the inheritance of traits (Khan *et al.*, 2009a). It works as a principal method for screening of germplasm and to determine the ability of the different genotypes to be included or not in a future breeding programme on the basis of their GCA, SCA and reciprocal effects. The yield advancement in brassica requires information regarding

the nature of different combining abilities of parents and also knows how about the nature of gene action involved in expression of different quantitative and qualitative traits of economic importance is also a prerequisite to develop and design desirable lines (Gupta *et al.*, (2011) and Dholu *et al.*, (2014). Zhang (1987) and Larik *et al.* (1999) reported that selection of parent cultivars for intraspecific hybridization is greatly facilitated by the utilization of GCA and SCA. In breeding programs, the GCA and SCA are usually used for parents and their cross combinations selection, respectively for improvement of crop production (Singh and Sachan, 2003). Therefore, desirable GCA and SCA are needed to achieve higher yield with heterosis (Marinkovi and Marjanovic, 2004). Many studies have been conducted to address the effects of GCA and SCA for yield and yield components in different crops (Khan *et al.*, 2009a and b; Muraya *et al.*, 2006). But the research studies regarding gene action for yield and yield components in brassica is unsolved and needs consideration. The present study aims to identify the best general combiners and their F_1 hybrids on the basis of their general, specific and reciprocal combining ability for yield and its contributing traits. Development of superior variety could be done by reshuffling the genes through hybridization from suitable parents. Moreover, it is also necessary to know about the nature and magnitude of gene action responsible for controlling the inheritance of various yield attributes along with combining ability of the parent and their cross combination in order to exploit them in further crop improvement programme.

MATERIALS AND METHODS

Ten parents *viz.* Varuna, Rohini, Vaibhav, Vardan, RH-819, Krishna, RH-9304, RGN-19, RH-9801 and RH-30 were crossed in half diallele fashion to produce 45 F_1 s. Ten parents and their 45 F_1 s were grown in a randomized block design with three replications. Each parent and F_1 s. were grow in single row of 4m 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 agronomic 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 days to flowering, plant height, number of primary branches, number of secondary branches, length of main raceme number of siliquae on main raceme, days to maturity, number of seed per siliqua, test weight, yield and oil content in each replication. The combining ability analysis was done by the procedure suggested by Griffing's (1956) Method 2, Model I. The mathematical model for the combining ability analysis is assumed to be:

$$Y_{ijkl} = u + g_i + g_j + s_{ij} + 1/bc \, d_i \, d_j \, e_{ijk} \quad (i, j) = 1, 2, 3 \dots n;$$

$$k = 1, 2, 3 \dots b;$$

$$l = 1, 2, 3 \dots c)$$

where,

Y_{ijkl} = mean of $i \times j$ th genotype in k th replication

u = the population mean

g_i = the general combining ability (gca) effect of i th parent

g_j = the gca effect of j th parent

s_{ij} = the specific combining ability (gca) effect for the cross between i th, j th parent such that $s_{ij} = s_{ji}$

$\sum_i \sum_j e_{ijkl}$ = the environmental effect associated with the $ijkl$ th individual observation on i th individual in the k th block with i th as female parent and j th 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.

RESULTS AND DISCUSSION

General combining ability (GCA) effect of parents was for all characters based on F_1 and F_2 generation are presented in Table 1 a & b. A significant differences among the parents with respect to their gca effect both the generations in days to flowering table 2. Parents RGN-19 followed by Krishna and Rohini in F_1 , Vaibhav followed by RH-9301 and RGN-19 in F_2 generation for earliness flowering were recorded good general combiner, while Variety RH-819 were recorded good combiner for late flowering.

The parents RH-819 followed by RH-9304, Vaibhav in F_1 RH-30 followed by RH-9304 and Vardan in F_2 were recorded good general combining parents for shortest plant height, whereas RH9801 followed by Krishna, RH-819 in F_2 were noticed good general combiner for tallest plant. The number of primary branches was recorded on the basis of general

combining effects. The parents Krishna, RH-9801, Vardan in F_1 generation and RH-819 and RH-9304 in F_2 were proved to be good general combiner. The parents RH-30, RGN-19, Vardan and RH-9801 showed significantly high GCA effect for large number of secondary branches, while the parents RH-819, Rohini, RH-9304 and Krishna showed negative value

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 vs F_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 vs F_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: Estimate the general combining ability for yield and yield attributing characters of mustard

Sr. No.	Parents	Days to flowering		Plant height		No of primary branches		No of secondary branches		Length of Main raceme		No of siliqua on main raceme		Days to maturity		No of seed per siliqua		Test weight		Oil content		Yield (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.	Varuna	0.660	0.400	-3.020	0.270	-0.200*	-0.030	0.100	0.150	1.420	3.060	-	4.160	0.290	-0.01	0.180	0.330*	0.160	0.260	0.430	0.380**	1.320	0.060
		**	**	**	*	*	*	*	*	*8	**	0.540*	**					**	**	**	**	**	**
2.	Rorini	-0.290	0.240*	1.820	5.940	0.000	-0.110	-0.660	-0.540	0.570	3.650	-1.070	3.570	0.120	-0.280	-0.210*	-0.080	0.030	-0.130	0.700	0.570**	0.410	-0.520
		*	*	**	**	*	*	**	**	**	**	**	**					**	**	**	**	**	**
3.	Vabhav	-0.01	-0.890	-3.570	2.430	-0.20	-0.00	0.050	-0.030	-0.340	0.830	0.170	1.580	-0.770	0.190	0.220*	-0.020	0.040*	-0.040	-0.420	0.260**	-0.840	-0.730
		**	**	**	**	*	*	**	**	**	**	**	**	**	**			**	**	**	**	**	**
4.	Vardam	0.610	-0.190	2.920	-3.250	0.060	0.030	0.330	0.100	0.970	-2.430	0.910	-2.150	0.910	0.020	0.210*	0.810	-0.150	-0.230	0.170*	0.520**	0.320	1.190
		**	*	**	**	*	*	**	**	**	**	**	**	**	**			**	**	**	**	**	**
5.	RH-819	0.280	1.060	-5.660	3.350	-0.050	0.150	-0.740	-0.380	1.290	0.230	-1.05	-0.140	0.510	0.990*	-1.30	-0.30	0.040*	0.040	0.300	0.060	-0.110	0.250
		*	**	**	**	*	*	**	**	**	*	**	*	**	**			**	**	**	*	*	*
6.	Krishna	-0.490	-0.150	3.310	5.570	0.140*	-0.170*	-0.010	0.000	-3.790	-0.870	-1.800	0.970	-0.080	-0.310	0.110	-0.070	-0.120	-0.050	-0.050	-0.780	-0.380	0.240
		**	**	**	**	*	*	**	**	**	**	**	**	**	**			**	**	**	**	**	*
7.	RH-9304	-0.050	-8.60	-0.520	-4.980	0.20	0.040	-0.110	0.090	-1.320	-0.810	0.320	-1.810	-0.150	-0.360	-0.040	0.100	-0.040*	0.160	-0.790	-0.540	-1.380	-0.200
		**	*	*	**	*	*	**	**	**	**	**	**	**	**			**	**	**	**	**	*
8.	RCN-19	-0.970	-0.210	1.680	-1.07	-0.080	-0.110	0.360	0.210*	0.780	-2.560	2.240	-1.690	-0.40	-0.170	-0.500	-0.680	0.030	0.020	-0.200	0.430**	0.410	0.370
		**	*	**	**	*	*	**	**	**	**	**	**	**	**	**	**	**	*	*	*	*	*
9.	RH-9801	0.230	0.750	5.170	-2.820	0.100	0.150	0.190*	0.050	2.790	0.110	2.570	-0.480*	-0.120	0.020	0.120	0.120	0.090	-0.020	0.310	-0.150*	0.850	0.410
		*	**	**	**	*	*	**	**	**	**	**	**					**	**	**	**	**	**
10.	RH-30	0.030	-0.140	-2.130	-5.450	0.030	-0.220*	0.500	0.270*	-2.36	-1.210	-1.740	4.020	-0.660	-0.100	0.130	0.470	-0.080	-0.010	-0.470	-0.280	-0.590	-1.080
		**	**	**	**	*	*	**	**	**	**	**	**	**	**			**	**	**	**	**	**
SE(g) ±		0.080	0.083	0.138	0.085	0.065	0.077	0.079	0.079	0.082	0.105	0.145	0.141	0.145	0.268	0.091	0.083	0.017	0.029	0.051	0.053	0.073	0.088
SE (gr-gr) ±		0.118	0.126	0.207	0.126	0.096	0.114	0.118	0.118	0.122	0.155	0.214	0.212	0.219	0.399	0.134	0.126	0.026	0.044	0.076	0.081	0.109	0.134

for GCA in both the generations. It is due additive and non-additive effect of genes. These finding also corroborated with the results of Dhuppe *et al.*, (2006), Bhandari *et al.*, (2007), Vagadiya *et al.*, (2010), Jethva *et al.*, (2011) and Bhadalia *et al.*, (2014) in mustard.

For the main length of raceme the parent RH-9801 followed by Varuna, RH-819, RGN-19, Vardan and Rohini in F_1 generation and Rohini, Varuna, Vaibhav and RH-819 in F_2 generations were recorded good general combining parents for bearing maximum length of main raceme. Significant differences were noted for number of siliqua on the main raceme in both the generations. Parents RGN-19 and Vardan showed maximum siliqua in F_1 and Varuna, Rohini, Vaibhav and Krishna in F_2 generation were recorded good general combining parents. Early maturity was consider desirable therefore parents were negative estimate of GCA effects were consider promising parent Vaibhav and RH-30 showed significant negative GCA in F_1 and parents RH-9304, Krishna, Rohini showed negative GCA effect in F_2 for maturity. Varieties RH-819, Vaibhav, Vardan and RH-9801 showed positive GCA effect and good combiner for late maturity. A significant GCA effect were recorded for number of seed per siliqua for the both the generation. The parents Vaibhav, Vardan, Varuna, in F_1 and Vardan RH-30 and Varuna in F_2 were recorded good general combining parents for bearing higher number of seed per siliqua.

The parent Varuna followed by RH-9304, Vaibhav in F_1 generation and Varuna followed by RH-9304 and RH-819 in F_2 were reported for higher test weight. A significant difference was noted for oil content in both the generation. The parents RH-9801, RH-819 in F_1 and Rohini, Vardan, Varuna and Vaibhav in F_2 were recorded good general combining parent for higher oil contents. The parents Varuna followed by RH-9801, Rohini, RNG-19, Vardan F_1 and Vardan followed by RH-9801, RNG-19 and RH-819 in F_2 were showed good general combining parent for higher yield per plant in both the generations.

The result indicated that the exploitation of the

both additive and non-additive types of gene action. It would be worthwhile to resort breeding methodologies such as biparental mating, recurrent selection or reciprocal recurrent selection, which would accumulate favourable genes in homozygous state or help in breaking linkage blocks thereby generating maximum variability for further selection. Similar finding were also reported by Gupta *et al.*, (2011) and Dholu *et al.*, (2014).

Conclusion :

The present investigation concluded that GCA effects were higher in magnitude for pods per plant, pod length and seed yield plant per plant indicating that these trait were governed by additive type of gene action. GCA effects were of higher magnitude for seeds pod per siliqua and test weight manifesting that maternal effect play crucial role for these traits. The importance of both additive and non-additive variability could not be ignored and the use of integrated breeding strategies is needed for the improvement of these traits for *Brassica juncea* genotypes.

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