Combining ability analysis for seed yield and its attributes in Indian Mustard [*Brassica juncea* (L.) Czern and Coss]

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The hybrids were developed by adopting diallel mating design excluding reciprocals involving ten Indian mustard genotypes during *Rabi* 2005-06. The resultant 45 hybrids along with their parents were evaluated in a Randomized Block Design with three replications under four environments *viz.,* timely sown at Sardarkrushinagar (E_1) and Ladol (E_2), and late sown at Sardarkrushinagar (E_3) and Ladol (E_4), during *Rabi* 2006-07. Combining ability analysis on pooled basis, revealed importance of both additive and non-additive genetic variances for the control of various traits. However, the ratio σ^2gca/σ^2sca indicated preponderance of non-additive gene action for days to 50 per cent flowering, days to maturity, seed yield per plant, biological yield per plant and harvest index, while additive gene action was preponderant for rest of the traits. The parents RK 9501, GM 1 and GM 2 were good general combiners, whereas, the crosses 'RK 9501 x GM 2', 'GM 1 x GM 3' and 'GM 3 x SKM 139' were found to be the best specific combinations for seed yield per plant and some of the important yield contributing traits. However, on the basis of *per se* performance, exploitable heterosis and significant sca effects for seed yield per plant and some of its important components, the above hybrids were considered to be the most promising for exploitation of heterosis.

Key words : *Brassica juncea,* Diallel, Combining ability, gca, sca

INTRODUCTION

Mustard is one of the most important edible *Rabi* oil seed crops. The genus *Brassica* belongs to Brassicaceac family and includes many crop species. Exploitation of heterosis in mustard has been recognized as a practical tool in providing breeders a means of improving yield and other important traits. The phenomenon of heterosis of F_1 hybrids can also reflect special combining ability (sca) and general combining ability gca of parental lines. Combining ability concepts are the basic tools for improved production of crops in the form of F1 hybrids. Identifying parental combinations with strong heterosis for yield and obtain genetic parameters are the most important steps in the development of new cultivars. Among different mating designs, diallel analysis is a systematic approach which has been widely used in crop plants for testing the performance of genotypes in hybrid combinations and also for characterizing the magnitude and nature of gene action involved in controlling quantitative characters (Grifing, 1956). The present Investigation was, undertaken with a view to estimate general and specific combining ability variances and effects in Indian mustard.

RESEARCH METHODOLOGY

The experimental material consisted of 10 parents and their 45 F_1s produced utilizing diallel mating design suggested by Griffing (1956) method I and method II, were developed at the Seed Technology Department, S.D. Agricultural University, Sardarkrushinagar during *Rabi* 2005-06 and the field experiments were conducted in a Randomized Block Design with three replications at the Seed Technology Department, S.D. Agricultural University, Sardarkrushinagar and the Agricultural Research Station, S.D. Agricultural University, Ladol during *Rabi* 2006-07 over four environments created by two staggered dates of sowing *viz.,* timely sown (16th October) at Sardarkrushinagar (E_1) and Ladol (E_2) and late sown (3rd November) at Sardarkrushinagar (E_3) and Ladol (E_4). All agronomic practices were adopted in order to a healthy

crop growth. A sample of five representative plants were taken from each plot for recording data on plant height, number of primary branches, number of secondary branches, length of main raceme, number of siliquae on main raceme, seed yield, 1000-seed weight, and oil content in each replication while data on days to 50 per cent flowering, days to maturity were recorded on plot basis. Mean values of sample for various traits were subjected to combining ability analysis.

RESEARCH FINDINGS AND ANALYSIS

The analysis of variance for combining ability for all the traits studied under four environments (Table 1) revealed that the mean squares due to general combining ability were found to be significant for all the traits in all the environments except for harvest index. The mean squares due to specific combining ability were found to be significant for all the traits studied in all the environments except for length of main branch in E_3 and E_4; number of branches per plant in all environments; number of siliquae per plant in E_2 and harvest index in E_1 and E_2.

On pooled basis, the ratios of gca and sca variance components (σ^2gca/σ^2sca) was less than unity for days to 50 per cent flowering, days to maturity, seed yield per plant,

biological yield per plant, harvest index and oil content. This indicated that non-additive type of gene action played greater role in the inheritance of these characters. The presence of predominantly large amount of non-additive gene action would necessitate the maintenance of heterozygosity in the population. Breeding methods such as biparental mating and *inter se* crossing between suitable lines followed by reciprocal recurrent selection may increase frequency of genetic recombinations and hasten the rate of genetic improvement. Whereas, the ratios of gca and sca variance components (σ^2gca/σ^2sca) was more than unity for plant height, length of main branch, number of branches per plant, number of siliquae per main branch, number of siliquae per plant and 1000 seed weight. The predominant role of additive gene action in the inheritance of plant height and length of main branch was observed by Singh (2005) and Shrivastava *et al.* (2009); for number of siliquae per main branch (Kumar and Thakral, 2003 and Singh, 2005, for number of siliquae per plant; Singh *et al.,* 2001 and Shrivastava *et al.,* 2009 and for 1000 seed weight (Bhatt, 2007).

This indicated that additive type of gene action played greater role in the inheritance of these characters. Breeding methods such as recurrent selection may increase frequency of genetic recombination and hasten the rate of genetic

Table 1: Analysis of variance (mean squares) for combining ability for different traits pooled over environments in mustard

Source of variation	d.f.	Characters					
		Days to 50 % flowering	Days to maturity	Plant height	Length of main branch	Number of branches/plant	Number of siliquae/ main branch
GCA	9	55.202**	147.921**	993.195**	427.148**	130.138**	430.977**
SCA	45	8.098**	18.481**	30.010**	11.766**	0.651	10.287**
Environments	3	102.022**	254.617**	521.095**	997.353**	73.193**	401.481**
GCA x E	27	2.619**	6.624**	13.359**	5.927**	1.074**	1.577**
SCA x E	135	1.174**	2.032**	6.024**	1.623	0.206	0.728
Error	432	0.447	0.680	3.713	1.990	0.537	0.832
σ^2_{gca}	-	1.141	3.068	20.614	8.857	2.700	8.961
σ^2_{sca}	-	1.913	4.450	6.574	2.444	0.029	2.364
$\sigma^2_{gca}/\sigma^2_{sca}$	-	0.596	0.689	3.136	3.624	94.720	3.791

Contd....Table 1

Source of variation	d.f.	Characters					
		Number of siliqua/ plant	1000 seed weight	Seed yield / plant	Biological yield/ plant	Harvest index	Oil content
GCA	9	14110.176**	13.447**	283.605**	3624.068**	24.199	12.606**
SCA	45	275.602**	0.246**	36.193**	528.152**	16.882	2.017**
Environments	3	5418.926**	0.539**	401.933**	5123.509**	14.828	7.935**
GCA x E	27	21.309	0.214**	9.614**	117.596**	15.261	0.553**
SCA x E	135	21.355	0.097**	4.472**	63.823**	28.189**	0.211**
Error	432	23.179	0.022	2.776	4.671	13.422	0.066
σ^2_{gca}	-	293.479	0.280	5.851	75.404	0.225	0.261
σ^2_{sca}	-	63.106	0.056	8.354	130.871	0.865	0.488
$\sigma^2_{gca}/\sigma^2_{sca}$	-	4.651	4.991	0.700	0.576	0.260	0.535

N.B. : * and ** indicate significance of values at P= 0.05 and P= 0.01, respectively.

improvement. Combining ability analysis pooled over environments revealed that mean squares due to GCA variance, SCA variance, GCA x environments and SCA x environments were significant for most of the characters.

The results on general combining ability effects on pooled basis (Table 2) revealed that the parents, RK 9501, GM 2, GM 3, GM 1 and SKM 139 were found to be good combiners for seed yield per plant as well as for some of its important component traits. SKM 149 was average general combiner for

seed yield per plant but was good general combiner for days to 50 per cent flowering, days to maturity, plant height and number of siliquae per plant. On pooled basis, parent GM 2 was good general combiner for earliness; Rai Kutch for dwarf ness; RK 9501 for length of main branch, number of branches per plant, number of siliquae per main branch number of siliquae per plant,1000 seed weight and biological yield per plant and GM 1 for harvest index and oil content.

The crosses, RK 9501 x GM 2, GM 1 x GM 3 and GM 3 x

Table 2: Estimates of general combining ability effects of parents for various traits of mustard in pooled environments

Sr. No.	Parents	Days to 50% flowering	Days to maturity	Plant height	Length of main branch	Number of branches/ plant	Number of siliquae/ main branch
1.	GM 1	-0.57**	0.33**	-2.79**	3.18**	1.53**	3.56**
2.	GM 3	-0.57**	-0.16	0.48	1.70**	0.75**	1.54**
3.	SKM 149	-0.64**	-1.97**	-2.30**	0.49**	0.17	0.59**
4.	SKM 139	-0.82**	-2.23**	-2.59**	-0.09	-0.53**	-0.18
5.	PM 67	0.72**	1.79**	3.04**	-1.16**	0.88**	-0.98**
6.	PCR 7	1.31**	0.17	3.37**	-2.36**	-1.15**	-2.07**
7.	CS 52	1.90**	1.73**	-1.16**	-3.55**	-2.21**	-3.43**
8.	Rai Kutch	-1.04**	-2.77**	-9.09**	-4.83**	-2.84**	-5.24**
9.	RK 9501	0.77**	1.48**	4.97**	4.31**	2.13**	4.02**
10.	GM 2	-1.06**	1.63**	6.08**	2.32**	1.27**	2.18**
	S.E. ±	0.09	0.11	0.26	0.19	0.10	0.12

Contd...Table 1

Sr. No.	Parents	Number of siliquae/plant	1000– seed weight	Seed yield/ plant	Biological yield/ plant	Harvest index	Oil content
1.	GM 1	20.83**	0.09**	2.70**	8.18**	1.37**	0.61**
2.	GM 3	9.81**	0.11**	1.49**	5.31**	-0.42	0.02
3.	SKM 149	1.50**	-0.06**	-0.00	-1.24**	0.54	-0.49**
4.	SKM 139	-2.80**	-0.09**	0.49*	1.21**	0.09	0.05
5.	PM 67	-5.90**	-0.39**	-1.21**	-2.95**	-1.20*	-0.99**
6.	PCR 7	-12.77**	0.02	-1.65**	-6.23**	0.30	0.36**
7.	CS 52	-20.62**	-0.19	-2.91**	-10.12**	-0.20	0.49**
8.	Rai Kutch	-26.25**	-1.04**	-4.01**	-14.35**	0.25	-0.46**
9.	RK 9501	26.45**	0.90**	3.48**	13.40**	0.07	0.49**
10.	GM 2	9.72 **	0.65**	1.63**	6.79**	-0.76	-0.12**
	S.E. ±	0.66	0.02	0.23	0.30	0.50	0.04

Table 3: Specific combining ability effects of some selected crosses for important characters

Sr. No.	Cross	Days to 50% flowering	Plant height	Number of siliquae/Plant	1000– seed weight	Seed yield/ plant	Oil content
1.	PM 67 x GM 2	-3.10**	0.03	-3.01	0.34**	-2.659**	-0.13
2.	SKM 149 x GM 2	0.00	-4.80**	2.97	0.16*	-0.910	-1.18**
3.	GM 1 x RK 9501	-098**	3.77**	25.10**	-0.03	5.848**	-0.18
4.	RK 9501 x GM 2	0.73*	1.50**	25.36**	-0.20**	8.928**	0.00
5.	GM 1 x PM 67	1.07**	0.14	-2.32	0.05	-1.692*	1.42**
6.	SKM 149 x SKM 139	-0.49	1.35**	3.12	0.56**	-1.160	-0.17
	S.E. ±	0.31	0.26	2.21	0.07	0.77	0.12

Table 4: Selected crosses and their performance for important characters

Cross	GCA effects		SCA effects
	P1	P2	
Seed yield / plant			
RK9501 x GM 2	3.48**	1.63**	8.298**
Days to 50 % flowering			
PM 67 x GM 2	0.72**	-1.06**	-3.10**
GM 1 x GM 2	-0.57**	-0.57**	-0.89**
Number of siliqua/ plant			
GM 3 x SKM 139	9.81**	-2.80**	15.36**

SKM 139 had significant positive sca effects on the basis of pooled over environments for seed yield per plant. Significant positive sca effects for seed yield have also been reported by Ghosh *et al.* (2002); Gupta and Narayan (2005) and Patel *et al.* (2005). Out of these, 'RK 9501 x GM 2' exhibited significant desirable sca effects for length of main branch, number of branches per plant, number of siliquae per main branch, number of siliquae per plant and biological yield per plant. The hybrid, 'GM 1 x GM 3' exhibited significant desirable sca effects for days to 50 per cent flowering, days to maturity, plant height, length of main branch, number of siliquae per main branch, number of siliquae per plant, biological yield per plant and oil content. The hybrid, 'GM 3 x SKM 139' exhibited significant desirable sca effects for length of main branch, number of siliquae per main branch, number of siliquae per plant and biological yield per plant. The crosses showing significant sca effects are expected to throw-off transgressive segregants in segregating generations, and thus, such crosses can be exploited for the improvement of yield and specific yield attributing traits.

The estimates of sca effects revealed that none of the hybrids was superior for all the characters. However, best three hybrids on the basis of sca effects for seed yield per plant over the environments were RK 9501 x GM 2, GM-1 x GM 3 and GM 3 x SKM 139. The highest sca effects in desired direction for different characters were exhibited by different hybrids *viz.,* PM 67 x GM 2 for days to 50 per cent flowering, PM 67 x RK 9501 for days to maturity, SKM 149 x GM 2 for plant height, GM 1 x RK 9501 for length of main branch, GM 1 x RK 9501 for number of branches per plant, GM 1 x RK 9501 for number of siliquae per main branch, RK 9501 x GM 2 for number of siliquae per plant, SKM 149 x SKM 139 for 1000 seed weight, RK 9501 x GM 2 for biological yield per plant, GM 1 x RK 9501 for harvest index and GM 1 x PM 67 for oil content (Table 3 and 4).

LITERATURE CITED

Bhatt, A.B. (2007). Genetics studies of quantitative and qualitative traits in Indian mustard [*Brassica juncea* (L.) Czern & Coss]. M.Sc. (Ag.) Thesis, Sardarkrushinagar Dantiwada Agricultural University, GUJARAT (INDIA).

Ghosh, S.K., Gulati, S.C. and Rajani, Raman (2002). Combining ability and heterosis for seed yield and its components in Indian mustard [Brassica juncea (L.) Czern & Coss]. *Indian J. Genet.*, **62**(1) : 29-33.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing system. *Australia J. Biol. Sci.*, **9:** 463-493.

Gupta, P.C. and Narayan, Shiv (2005). Potential crosses for development of hybrid varieties in Indian mustard [*Brassica juncea* (L.) Czern & Coss]. *J. Oilseeds Res.*, **22**(1): 164-167.

Kumar, Ramesh and Thakral, N.K. (2003). Genetic architecture of length of main raceme and siliquae on main raceme in Indian mustard. *Haryana agric. Uni. J. Res.*, **33**(2): 125-128.

Patel, K.M., Sharma, G.S., Pathak, H.C. and Thakkar D.A. (2005). Combining ability analysis over environments in Indian mustard, *Brassica juncea* (L.) Czern & Coss. *J. Oilseeds Res.*, **22**(1) : 15-17.

Shrivastava, S.B., Shekhar, R., Singh, M. and Rao, M. (2009). Combining ability analysis for seed yield and yield contributing characters in Indian mustard [*Brassica juncea* (L.) Czern & Coss]. *J. Oilseeds Res.*, **26** (special) : 58-60.

Singh, D., Mishra, V.K. and Sinha, T.S. (2001). Genetic architecture of yield and its contributing characters in yellow sarson (*Brassica campestris* Linn. var. Yellow Sarson Prain). *Indian J. agric. Res.*, **35** (4) : 263-266.

Singh, Mahak (2005). Genetic analysis for gene action in Indian Mustard [*Brassica juncea* (L.) Czern & Coss]. *Plant Archives*, **5**(1): 77-80.