Combining ability analysis in Indian mustard (Brassica juncea L. Czern & Coss.)

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Combining ability analysis in Indian mustard (*Brassica juncea* L. Czern & Coss.)

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ABSTRACT

A line x tester analysis involving five males (lines) and 10 female (testers) parents were carried out for five traits in Indian mustard. (*Brassica juncea* L. Czern & Coss.). Among the parents, MCN-75, Ornamental Rai, Rohini, Kranti, Vardan, RH-8812, and NDR-8501 were found to be significantly superior general combiners for seed yield and yield components. The cross MCN-75 x Rohini, MCN-75 x NDR-8501, MCN-75 x Vardan and MCN-73 x Kranti showed high heterosis for seed yield and some of the yield contributing traits. The cross MCN-75 x RH-8812, MCN-73 x Pusa Bold, Ornamental Rai x NDR-8501 and MCN-70 x RH-8813 had higher *sca* effects. For most of the major characters including seed yield both additive and non-additive gene action were of prime importance.

Key words: *gca* effects, Heterobeltiosis, Mid-parent heterosis, Mustard *sca* effects

Indian mustard (*Brassica juncea* L. Czern & Coss.) is one of the most important oilseed crops grown during winter season. The realisable yield potential in this crop based on various observations is reported to be much more than what has been achieved so far. The increase in productivity through breeding efforts has not been adequate because of hybridization. Heterosis breeding could be a potential alternative for achieving quantum jumps in production and productivity. Since, commercial exploitation of heterosis in several crop plants has caused a major breakthrough in yield levels. The magnitude of heterosis particularly for yield is of paramount importance and if the heterosis is practically and economically feasible it can help to reach high yield levels in mustard. Information about general and specific combining ability effects is very important in making the next phase of a breeding program. It is necessary to have detailed information about the desirable parental combination in any breeding program which can reflect a high degree of heterotic response. Therefore, heterotic studies can provide the basis for the exploitation of valuable hybrid combinations in future breeding programs in brassica. The main Objective of the present study was to identify the best combiners and their crosses on the basis of their general, specific combining ability and high heterotic crosses for yield and its component traits. The present study was undertaken to select parents for effective hybridization programme as well as rapid selection advance in segregating generations.

The experiment was conducted at crop improvement research of Banaras Hindu University, Varanasi. The experimental material consisted of five lines (MCN-129, MCN-70, MCN-73, MCN-75 and Ornamental Rai) and 10 (Varuna, Vardan, Kranti, Pusa Bold, Rohini, RH-8812, RH-8813, RH-8814, RLM-1359 and NDR-8501) testers were selected on the basis of phenotypic diversity in respect of yield and yield components from the genetic stock of mustard. The lines were selected on the basis of their reaction to leaf blight; all the lines taken in the present investigation were tolerate to leaf blight. But they suffer from low productivity. These 15 genotypes were sown in a crossing block during winter season of 2003. The line x tester model of mating design was adapted to produce 50 F_1 hybrids. These 50 F_1 hybrids along with their 15 parents were sown in a randomized block design with two replications during winter season of 20045. Each entry was sown in a single row of 4.5 m length at spacing of 45 cm x 10 cm. Five competitive plants were selected randomly from each plot for recording observations on length of siliqua, number of siliquae/plant, number of seeds/siliquae, seed yield/plant and for 1000-seed weight. The data were subjected to analyses of variance according to Steel and Torrie (1980). The estimates of combining ability effects were computed as per procedure suggested by Griffing (1956).The estimate of heterosis over the mid-parent and better-parent was calculated using the procedure of Matzingar *et al.* (1962).

The analysis of variance (Table 1) revealed significant differences for all the characters except length of siliqua studied in case of lines, which indicated the existence of genetic diversity in the parental materials. On the other hand, among testers highly significant differences were observed for number of siliquae/plant and numbers of seeds/siliqua.The mean squares due to females were found to be smaller than those due to males except seed yield/plant, length of siliqua and 1000-seed weight (Table 1). Variations among line x tester interactions were significant for all the characters except seed yield/plant and length of siliqua. This indicated the manifestation of parental genetic variability in their crosses and presence of uniformity among the hybrids.

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The variance due to *sca* was found to be considerably higher than that of *gca* for all characters except number of siliqua/plant, indicating greater importance of non-additive gene action for exploitation of heterosis.

General combining effects of all lines and testers are presented in table 2. For seed yield the genotypes appeared as best general combiners were MCN-75, Rohini, Kranti, Vardan and NDR-8501 (Table 3). Among the parents, Rohini was found to be good general combiner for other contributing traits like, number of siliquae/plant and number of seeds/siliqua. The genotypes Kranti and NDR-8501 were the best general combiner for number of siliquae/plant and seed yield/plant. The genotype RH-8812 was the best general combiner for 1000-seed weight.

Specific combining ability effect estimates revealed a very wide range of variation for all the characters. The crosses with significant desirable *sca* effects are presented in Table 4. Cross combinations MCN-70 x Rohini, MCN-70 x Vardan, MCN-70 x RH-8813 and MCN-129 x Varuna had high significant *sca* effect for seed yield coupled with high *gca* of female parent for seed yield and major yield components. Therefore, both additive and non-additive type of gene action seemed to influence seed yield. Similar results were also reported by Satwinder *et al.* (2000). Oian *et al.* (2003). Crosses like, MCN-73 x Pusa Bold and MCN-70 x Pusa Bold were the best specific combiners for number of siliquae/plant. Teklewold and Becker (2005), found significant specific combining (SCA) effects for number of siliquae/plant, whereas, MCN-75 x RH-8812 and Ornamental Rai x Varuna for number of seeds/siliqua Teklewold and Becker (2005) reported that *gca* of parents and *sca* of F_1's hybrids was significant for seeds/siliqua. Kumar *et al.* (2002) and Yadav *et al.* (2004) also reported similar results. Crosses Ornamental Rai x RLM-1359, Ornamental x NDR-8501 and Ornamental Rai x Vardan were the good specific combiners for length of siliqua Teklewold and Becker (2005), found significant specific combining effects for length of siliqua. Crosses MCN-73 x Pusa Bold, MCN-70 x RLM-1359 and MCN-129 x Varuna also performed as the best specific combiner for 1000-seed weight.

Table 1 Analysis of variance for combining ability analysis in Indian mustard

Source of variation	D. F.	Mean Sum of Square				
		No. of siliquae/plant	No. of seeds/siliqua	Seed yield/plant	Length of siliqua	1000-seed weight
Females	9	13401.82**	2.37**	12.94**	0.13	0.76**
Males	4	3451.90**	4.66**	0.57	0.11	0.42
Female x Male	36	2368.25**	3.83**	1.12	0.13	0.97**
Error	49	335.02	0.52	0.78	0.08	0.23

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

Table 2 Estimates of general combining ability effects in line x tester analysis in Indian mustard

Parent	No. of siliquae/plant	No. of seeds/siliqua	Seed yield/plant	Length of siliqua	1000-seed weight
Line					
MCN-129	-3.97	0.20	0.13	0.04	0.12
MCN-70	-7.12	-0.48*	-0.26	-0.05	0.19
MCN-73	-4.97	-0.55*	-0.05	-0.09	-0.04
MCN-75	23.36**	0.30	0.16	-0.02	-0.12
O R.	-7.321	0.52*	0.02	0.10	-0.13
Male					
CD (P=0.05)	12.34	0.48	0.59	0.18	0.32
CD (P=0.01)	21.68	0.85	1.04	0.33	0.87
Testers					
Varuna	-64.92**	0.10	-1.70**	0.03	0.23
Pusa Bold	-55.88**	-0.20	-2.31**	-0.06	-0.13
Vardan	21.00*	0.00	0.48	0.01	-0.41*
RH-8812	-2.34	-0.02	-0.17	0.06	0.43*
RH-8813	9.08	-0.42	0.05	0.14	-0.43*
RH-8814	-18.50*	-0.40	0.21	0.13	0.25
Rohini	47.68**	1.10*	1.13**	-0.07	0.09
Kranti	22.70*	-0.24	0.95**	-0.26*	-0.05
NDR-8501	31.02*	-0.46	0.77**	-0.09	0.03
RLM-1359	10.12	0.52	0.58	0.05	0.03
Female					
CD (P=0.05)	15.00	0.59	0.72	0.26	0.39
CD (P=0.01)	23.08	0.91	1.11	0.46	0.60

*, ** Significant at 5% and 1% level, respectively; O R = Ornamental Rai

Table 3 Superior general combiners for different characters in Indian mustard

Character	Lines (Males)	Testers (Females)
No. of siliquae/Plant	MCN-75	Rohini, NDR-8501, Kranti, Vardan
No. of seeds/Siliqua	Ornamental Rai	Rohini
Seed yield/Plant	MCN-75	Rohini, Kranti, NDR-8501
Length of siliqua	-	-
1000-seed weight	-	RH-8812

Table 4 Estimates of specific combining ability effects in line x tester analysis in Indian mustard

Crosse	No. of siliquae/plant	No. of seeds/siliqua	Seed yield/plant	Length of siliqua	1000-seed weight
O. R. x Varuna	11.01	2.44**	-0.12	-0.07	-0.28
O. R. x Pusa Bold	14.16	0.22	0.32	0.07	-0.55
O. R. x Vardan	-13.79	2.09**	0.69	0.31	-0.38
O. R. x RH-8812	-10.12	-2.96**	0.60	-0.26	0.26
O. R. x RH-8813	-1.24	-1.78**	-0.29	-0.03	0.17
O. R. x RH-8814	-8.13	-1.26*	0.07	-0.03	0.08
O. R. x Rohini	-9.48	-1.48*	-0.99	-0.64*	0.21
O. R. x Kranti	-24.23	-0.61	0.27	-0.24	-0.06
O. R. x NDR-8501	49.34**	2.24**	0.71	0.33	-0.28
O. R. x RLM-1359	-7.48	1.12	-0.07	0.56*	0.03
MCN-129 x Varuna	0.49	0.04	0.85	0.15	0.66
MCN-129 x Pusa Bold	-41.36*	0.42	-1.16*	0.09	-0.57
MCN-129 x Vardan	38.49*	-0.21	0.63	-0.22	0.02
MCN-129 x RH-8812	11.46	0.24	-0.16	0.11	0.10
MCN-129 x RH-8813	-9.06	-0.48	-0.16	-0.11	-0.29
MCN-129 x RH-8814	49.73**	0.36	0.67	-0.10	0.08
MCN-129 x Rohini	-48.42**	-0.56	-0.44	-0.26	-0.19
MCN-129 x Kranti	-37.87**	-0.69	-0.52	0.18	-0.36
MCN-129 x NDR-8501	34.10*	0.36	0.77	0.11	0.02
MCN-129 x RLM-1359	2.48	0.54	-0.48	0.09	0.43
MCN-70 x Varuna	21.18	1.26*	-0.81	0.17	0.12
MCN-70 x Pusa Bold	62.26**	-0.36	0.24	-0.09	-0.35
MCN-70 x Vardan	-3.69	0.21	0.91	0.00	0.38
MCN-70 x RH-8812	-65.72**	-1.14	-1.16*	0.13	0.46
MCN-70 x RH-8813	-14.64	0.04	0.81	-0.19	-0.63
MCN-70 x RH-8814	0.59	0.94	-0.53	0.28	-0.40
MCN-70 x Rohini	2.84	0.22	1.39*	0.27	0.23
MCN-70 x Kranti	3.19	-2.51**	-0.93	-0.44*	0.06
MCN-70 x NDR- 8501	-37.64**	0.54	-1.16*	-0.01	-0.36
MCN -70 x RLM-1359	31.04*	0.82	-1.23*	-0.08	0.45
MCN-73 x Varuna	-13.89	-0.86	0.05	0.18	0.16
MCN-73 x Pusa Bold	68.46**	0.82	0.29	0.12	0.89*
MCN-73 x Vardan	-36.69*	0.39	-0.51	-0.04	-1.08*
MCN-73 x RH-8812	-23.32	-0.66	-0.07	-0.06	-0.40
MCN-73 x RH-8813	5.46	0.32	0.24	-0.18	0.41
MCN-73 x RH-8814	18.39	-1.72**	-0.60	-0.40	0.20
MCN-73 x Rohini	-34.46**	1.36*	0.24	0.04	-0.17
MCN-73 x Kranti	21.99	0.63	-0.08	0.28	0.26
MCN-73 x NDR-8501	23.06	0.08	0.57	-0.09	0.04
MCN-73 x RLM 1359	-28.96	-0.34	-0.12	0.19	-0.35
MCN-75 x Varuna	-49.73**	-0.90	-0.13	-0.10	-0.48
MCN-75 x Pusa Bold	-12.68	-0.42	0.19	0.19	0.25
MCN-75 x Vardan	47.97*	-0.35	0.37	0.08	-0.02
MCN-75 x RH-8812	12.14	2.91**	0.37	0.01	0.16
MCN-75 x RH-8813	2.32	-1.22*	-0.80	-0.16	0.07
MCN-75 x RH-8814	-30.23*	-0.28	0.55	-0.04	-0.18
MCN-75 x Rohini	-1.28	-0.20	-0.09	0.25	0.15
MCN-75 x Kranti	4.67	1.07	-0.84	0.09	0.38
MCN-75 x NDR-8501	6.74	-1.58*	0.73	-0.23	-0.04
MCN-75 x RLM-1359	20.12	1.00	-0.35	-0.05	-0.33
CD (P=0.05)	30.10	1.19	1.12	0.40	0.79
CD (P=0.01)	42.56	1.68	2.05	0.65	1.12

Crosses with significant and desirable better parent heterosis (BPH) and mid parent heterosis (MPH) for different characters, were computed to identify the superior cross combinations for their potential use in hybrid breeding (Table 5). This experiment showed the presence of significant desirable better parent (BPH) and mid parent heterosis (MPH) for a good number of crosses for different characters. For seed yield, MCN-75 x NDR-8501 expressed the highest better parent heterosis (BPH) of 31.81% and cross MCN-75 x Rohini showed the highest mid parent heterosis (MPH) of 55.20%. For number of siliquae/plant cross MCN-73 x Rohini expressed the highest better parent heterosis (BPH) of 41.99% and cross MCN-73 x Vardan expressed the highest mid parent heterosis (MPH) of 39.08%. Thakur *et al.* (1997) and Satwinder *et al.* (2000) reported that F_1 generations expressed significant heterosis for number of siliquae/plant. Cross MCN-73 x Kranti expressed the highest better parent heterosis (BPH) of 15.29% for number of seeds/siliqua and cross Ornamental Rai x Vardan expressed the highest mid parent heterosis (MPH) of 33.66%. For length of siliqua none of the cross expressed the better parent heterosis (BPH) but cross Ornamental Rai x NDR-8501 expressed the highest mid parent heterosis (MPH) of 16.85%. The positive heterosis is desirable for length of siliqua was reported by Dharmendra and Mishra (2001) and Kumar *et al.* (2002). Cross MCN-73 x Vardan and Ornamental Rai x Vardan expressed the highest better (BP) parent and mid parent (MP) heterosis of 43.90% and 24.70% for 1000-seed weight In brassica positive heterosis is desirable for 1000-seed weigh was reported by Yadav *et al.* (2004).

In most of the crosses had very low *sca* effects but one of the parents had high *gca*. Hence, in these crosses heterosis for seed yield may be due to predominance of additive gene action and better selection advance can be expected in subsequent generations. Therefore, it may be possible to utilize heterobeltious in hybrid breeding as well as heterosis may be fixed in subsequent generations.

For the major yield contributing characters namely, number of siliquae/plant, number of seeds/siliqua, length of siliqua and 1000-seed weight the better parent heterosis was either due to high *gca* effects of the parents or due to high *sca* effects of the respective cross. The role of both additive as well as non-additive gene action for better parent heterosis expression was evident suggesting the development of heterotic combination for use in hybrid breeding programme. Results of the present study suggested some concept on breeding methodology to be followed in mustard and cross combination to be followed for further improvement. Seed yield and yield contributing traits showed the significant of additive and non-additive type of gene action in different cross combinations for different characters. The presence of additive gene action suggested that a part of the heterosis can be fixed in subsequent generations to take advantages in further selection. The predominance of non-additive gene action, however brought out that heterosis component could be exploited in hybrid development in Indian mustard.

Table 5 Heterotic effects for number of siliquae/plant, number of seeds/siliqua, length of siliqua, 1000 seed weight and seed yield/plant in *Brassica juncea* L. genotypes

Trait	Number of crosses with				Crosses with	
	Heterosis over		Significant heterosis over		The highest heterosis in rank order over	
	MP* (% range)	BP * (% range)	MP	BP	MP	BP
No. of siliquae/plant	29 (1.31 to 39.08)	25 (0.93 to 41.99)	16	13	MCN-73 x Vardan	MCN-73 x Rohini
No. of seeds/ siliqua	26 (1.63 to 33.66)	16 (2.90 to 15.29)	16	14	O.R. x Vardan	MCN-73 x Kranti'
Length of siliqua	18 (0.00 to 16.85)	0	8	00	O.R. x NDR-8501	None
1000-seed weight	38 (2.17 to 24.70)	45 (2.44 to 43.90)	12	08	O.R. x Vardan	MCN-75 x Vardan
Seed yield/plant	39 (0.74 to 55.20)	17 (0.00 to 31.81)	19	05	MCN-75 x Rohini	MCN-75 x NDR-8501

MP = mid-parent, BP = Better parent, O.R.=Ornamental Rai

REFERENCES

Dharmendra Singh and Mishra V K 2001. Heterosis and inbreeding depression in inter specific hybrids of yellow sarson [*Brassica campestris* (L.) var. Yellow sarson prain]. *Research on Crops*, **2**(3): 419-422.

Griffing B 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Australian Journal of Biological Science*, **9**: 463-493.

Kumar C, Muralia S and Deepak Gupta 2002. Heterosis studies in Indian mustard [*Brassica juncea* (L.)]. *Cruciferae Newsletter*, **24**: 59-60.

Matzingar D F, Mann T J and Cocker ham C C 1962. Diallel crosses in Nicotiana tabaccum. *Crop Science*, **2**: 383-86.

Oian W R, Liu and Meng J 2003. Genetic effects on biomass yield in interspecific hybridization between *B. napus* and *B. rapa*. *Euphytica*, **134**: 9-15.

Satwinder K, Paramjit S, Gupta V P, Kaur S and Singh P 2000. Combining ability analysis for oil yield and its components in *Brassica napus* L. *Cruciferae Newsletter*, **22**: 67-68.

Steel R G D and Torrie J H 1980. *Principles and Procedures of Statistics : A Biometrical Approach,* 2nd Ed. McGrow-Hill Book, New York.

Teklewold A and Becker H C 2005. Heterosis and combining ability in a diallel cross of Ethiopian mustard inbred lines. *Crop Science*, **45**: 2629-2635.

Thakur S K and Sagwal J C 1997. Heterosis and combining ability in rapeseed (B.N.L.). *Indian Journal of Genetics*, **57**(2): 163-167.

Yadav I S, Chauhan Y S and Kumar K 2004. Heterosis for seed yield and its components in Indian mustard [*Brassica juncea* (L.) Czern & Coss]. *Journal of Maharashtra Agricultural Universities*, **29**(2): 217-218.