Journal of Oilseed Brassica, 16(1) : 40-45, January, 2025

Line x tester analysis for combining ability in Indian mustard [*Brassica juncea* (L.) Czern & Coss]

Ramesh Kumar[1*], PKP Meena[2], Ruchi Bishnoi[3] and Kamal Kumar Sharma[4]
[1,3,4]*Department of Genetics and Plant Breeding, College of Agriculture, Ummedganj-Kota Agriculture University, Kota, Rajasthan, India*
[2]*Department of Genetics and Plant Breeding, ARS, Ummedganj-Kota, Agriculture University, Kota, Rajasthan, India*
[*]*Corresponding author : yramesh617@gmail.com*
(Received: 16 November 2024; Revised: 20 December 2024; Accepted: 28 December 2024)
https://doi.org/10.56093/JOB.v16i1.5

Abstract

Line × tester analysis was carried out to estimate combining ability of 36 hybrids developed by crossing 9 lines with 4 testers of Indian mustard. Estimates of GCA effects indicated that Kranti, RH-749, Pusa Mustard-30 and Pusa Mahak and Tester, PM-27 were good general combiner. Significant SCA effects for seed yield per plant and other attributing traits in desirable direction were recorded in a series of hybrids and a close association between SCA effects and heterosis was observed amongst the best hybrids identified on the basis of SCA effects. The three hybrids; PM- 30 x CS 54, NRCHB 101 x PM 27, RH 749 x JM 1, IC-597889 x JM-1 and RH-30 x CS-54 exhibited highly significant SCA effects and higher *per se* performance for seed yield and important traits. The high yielding cross combinations can be further exploited for improving the seed yield by development superior genotypes.

Keywords *: General combining ability, Indian mustard, line x tester, specific combining ability*

Introduction

Brassica juncea L. is an important oilseed crop plays a crucial role in edible oil economy of India and occupies premier position in Indian agriculture. It is major *rabi* oilseed crop of the Indian subcontinent occupies more than 80% of the total rapeseed-mustard cultivated area. Contributes nearly 27% of edible oil pool in India and accounts for more than 13% of the global edible oil production (Meena *et al*., 2014 and Pratap *et al*., 2014). Improving the genetic potential of crop for increasing yield with quality characters should be over emphasized. line × tester analysis which involves 'l' line and 't' tester is an extension of the analysis of two factorial experiment developed by Kempthorne (1957), which provides a reliable information on the general and specific combining ability effects of parents and their hybrid combinations are used to generate the information. Information on combining ability provides guidelines to the plant breeder in selecting the elite parents and desirable cross combinations to be used in the formulation of systematic breeding programme.

Materials and Methods

The experiment was carried out at Agricultural Research Station, Ummedganj, Kota, Agriculture University, Kota during 2021-22 and 2022-23. The experimental material consisted of 36 F_1 s of Indian mustard (*Brassica juncea* L.) involving 9 lines namely RH-749, DRMRIJ-31, NRCHB 101, Kranti, Pusa Mustard-30, PusaMahak, PusaTaraka, RH 30, IC-597889 and four testers *viz*., Pusa Mustard-27, JM-1, CS-54 and EJ-20 were crossed in line × tester design during 2021–22. The aim of the present study was to evaluate GCA and SCA of high yielding varieties and breeding lines. The crosses along with their parents were planted in randomized complete block design with three replications during *rabi* 2022-23. The treatments were raised in rows of 4m length with a distance of 30cm between rows and 10cm between plants. The recommended package and practices were followed during the crop period.

Observations were recorded on thirteen quantitative traits, *viz*., days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of siliquae per plant, siliqua length (cm), number of seeds per siliqua, 1000-seed weight (g), biological yield per plant (g), seed yield per plant (g), harvest index (%) and oil content (%). Observations on days to 50% flowering and maturity were recorded on per plot basis and the observations on remaining traits were recorded on randomly selected five competitive plants in each replication. The combining ability analysis was carried out as per the method of Kempthorne (1957).

Results and Discussion

Analysis of variance for combining ability are presented in table 1. The components of variance attributable to lines and testers were used as a measure of general combining ability effects and the variance due to interaction between lines and testers was used as a measure of specific combining ability effects. The analysis of variance for combining ability that significant mean sum of squares due to crosses for all the traits indicated difference among crosses for traits under study. The mean sum of squares due to line x tester interaction was also found significant for all the traits except for plant height under study. Akabari *et al*., (2017), Malviya *et al*., (2019) and Choudhary *et al*., (2020) also reported significant mean square due to lines, testers and line × tester for seed yield and it's contributing characters.

General combining ability

A perusal of general combining ability (gca) effects of parents indicated that none of the parent was found to be good general combiner for all the traits (table 2). However, one of the line Kranti was found to be a good general combiner for seven characters *viz*., plant height, number of siliquae per plant, length of siliqua, no. of seed per siliqua, 1000- seed weight, biological yield per plant and seed yield per plant by exhibiting desirable significant positive gca effect.

Line RH-749 (for days to 50% flowering, days to maturity, number of secondary branches per plant, length of silique, no. of seed per siliqua and seed yield per plant) and Pusa Mustard-30 were observed to be good general combiners for four characters *viz*., no. of primary branches per plant, length of siliqua , 1000-seed weight and harvest index; line Pusa Mahak were observed to be good general combiners for four characters *viz*., days to 50% flowering, no. of secondary branches per plant, no. of silique per pant and oil content. Tester, PM-27 exhibited significant desirable GCA effects for days to 50% flowering, no. of silique per plant, no. of seed per siliqua, 1000- seed weight, biological yield per plant and seed yield per plant.It can be concluded that parent Kranti, RH-749, Pusa Mustard-30 and Pusa Mahak and Tester, PM-27 possess desirable alleles for most of the characters. Hence, these parents could be used in future breeding programme for improvement of respective characters.Similar results also found by Kaur *et al*., (2019), Choudhary *et al*., (2020) and Kaur *et al*., (2020).

Specific combining ability

None of the cross combination was found to be a common combiner for all the characters under study (table 3). Cross combination IC-597889 X EJ 20 showed highly significant desirable negative specific combining ability (sca) effects

Table 1: Analysis of variance for combining ability for different traits in mustard

Sources	df	Mean sums of squares												
		DF	DM	PH	NPBPP	NSBPP	NSPP	LS	NSPS	SW	BYPP	GYPP	HI	OC
Crosses	35	15.53**	7.57**	143.0*	1.03**	7.23**	1548**	0.23**	1.56**	0.73**	235.60**	5.47**	14.45**	1.60**
Line effects	8	16.78	6.34	211.61	0.76	7.25	770.45	0.25	2.10	1.02	364.17	5.30	20.55	3.21*
Tester effect	3	18.15	6.40	53.20	1.78	3.70	1768.87	0.12	3.91*	0.45	296.25	12.47	3.03	1.74
L x T effect	24	14.78**	8.12**	131.36	1.02**	7.66**	1779.5**	0.24**	1.09**	0.67**	185.10**	4.65**	13.85**	1.04**
Error	70	0.94	1.09	84.29	0.06	0.24	352.14	0.06	0.08	0.00	51.65	1.00	2.762	0.16

* and ** represent level of significance at 5 and 1%, respectively;DF= Days to 50 % flowering; DM= Days to maturity; PH= Plant height; NPBPP= Number of primary branches per plant; NSBPP= Number of secondary branches per plant; NSPP= Number of siliqua per plant; LS= Length of siliqua; NSPS = Number of seed per siliqua; SW = 1000-seed weight; BYPP = Biological yield per plant; GYPP= Grain yield per plant; HI= Harvest index; OC= Oil content

Table 2 : Estimates GCA effects of parents for yield and its attributing traits in mustard

Parents	DFF	DM	PH	NPBPP	NSBPP	NSPP	LS	NSPS	1000SW	BYPP	SYPP	HI	OC
LINES													
RH-749	-0.657 *	-1.157**	-2.385	-0.032	0.859**	-2.270	0.182 *	0.517**	0.060	-0.169	1.580**	0.728	-0.094
DRMRIJ-31	-0.574 *	0.593 *	-4.868 *	0.093	-0.328	-12.083 *	0.040	-0.096	0.255**	8.372**	-0.170	-2.832**	-0.152
NRCHB-101	-1.074**	-0.407	-4.181	0.160	-0.445*	-5.662	0.007	-0.646**	0.020	2.197	0.261	-0.414	0.503**
Kranti	0.343	0.593 *	6.594**	-0.166	0.144	12.421*	0.190*	0.510**	0.276**	6.764**	1.035**	-0.432	-0.447**
PM-30	-0.157	0.926**	-4.257	0.434**	-0.191	4.433	0.207**	-0.206	0.435**	-5.303*	-0.060	1.606**	-0.734**
P. Mahak	-0.991**	0.009	0.608	0.159	1.54**	12.499 *	-0.011	0.144	-0.046	-1.261	0.050	0.504	0.309 *
P. Tarak	0.009	0.426	5.075 *	-0.157	-1.09**	0.989	-0.056	0.278 *	-0.090 *	2.497	0.172	-0.708	0.528**
RH-30	2.843**	0.009	2.280	-0.416**	-0.108	0.717	-0.293**	0.420**	-0.615**	-6.119**	-0.578	1.136 *	-0.566**
IC-597889	0.259	-0.991**	1.134	0.209	-0.378*	-0.307	-0.070	0.184	-0.144**	-6.978**	-1.289**	0.411	0.653**
SE	0.2651	0.2853	2.3904	0.1202	0.1766	5.2806	0.0745	0.1064	0.0402	2.2233	0.2971	0.5436	0.1276
Gi-gi	0.3749	0.4034	3.3806	0.1699	0.2498	7.4680	0.1054	0.1505	0.0568	3.1443	0.4202	0.7687	0.1804
TESTERS													
PM-27	-0.991**	0.065	1.754	0.130	0.095	10.078**	0.075	0.476**	0.110**	4.430**	0.926**	-0.180	0.110
JM-1	1.009**	0.546**	-1.286	-0.348**	0.084	0.146	-0.070	-0.323**	0.055 *	0.089	0.054	0.278	0.015
CS-54	-0.102	0.028	0.499	0.244**	-0.52**	-9.732**	0.036	-0.292**	-0.187**	-1.019	-0.342	-0.383	0.232**
EJ-20	0.083	-0.639**	-0.967	-0.026	0.346**	-0.493	-0.041	0.139	0.023	-3.500*	-0.639**	0.285	-0.358**
SE	0.1767	0.1902	1.5936	0.0801	0.1178	3.5204	0.0497	0.0709	0.0268	1.4822	0.1981	0.3624	0.0850
Gi-gi	0.2499	0.2689	2.2537	0.1133	0.1665	4.9786	0.0702	0.1003	0.0379	2.0962	0.2801	0.5125	0.1203

* and ** represent level of significance at 5 and 1%, respectively

Table 3 : Estimates of sca effects of top three combinations for thirteen characters in Indian mustard

Cross combination	Specific combining ability effects	General combining ability effect of parents
Days to 50% flowering		
IC-597889 X EJ 20	-3.25**	P x P
P. Mahak X CS 54	-2.89**	G x A
RH- 30 X PM-27	-2.73**	P x G
Days to maturity		
P. Tarak X EJ 20	-2.73**	P x G
NRCHB 101 X PM 27	-1.81**	A x P
PM- 30 X PM-27	1.80**	P x P
Plant height		
IC-597889 X EJ 20	12.98**	A x P
NRCHB 101 X CS 54	9.53*	P x A
DRMRIJ-31 X EJ 20	7.32	P x P
No. of primary branches per plant		
PM- 30 X PM-27	1.26**	G x A
Kranti X EJ 20	1.05**	P x P
P. Mahak X PM-27	0.70**	A x A
Number of secondary branches per plant		
PM-30 X PM-27	2.58**	P x A
NRCHB-101 X CS-54	2.11**	P x P
Kranti X EJ-20	1.75**	A x G
Number of siliqua per plant		
NRCHB 101 X CS 54	35.15**	P x P
DRMRIJ31 X CS 54	33.38**	P x P
PM- 30 X PM-27	33.18**	A x G
Length of siliqua		
IC-597889 X EJ 20	0.47**	P x P
RH 749 X CS 54	0.42**	G x A
DRMRIJ-31 X JM 1	0.33**	A x P
Number of seed per siliqua		
NRCHB 101 X EJ 20	1.01**	P x A
P. Tarak X PM-27	0.65**	G x G
IC-597889 X CS 54	0.62**	A x P
1000-seed weight		
IC-597889 X PM-27	0.80**	P x G
P. Mahak X JM 1	0.57**	P x G
P. Tarak X PM-27	0.49**	P x G
Biological yield per plant		
Kranti X EJ 20	16.79**	G x P
RH- 30 X CS 54	13.41**	P x P
DRMRIJ-31 X JM 1	12.76**	G x A
Seed yield per plant		
PM- 30 X CS 54	2.40**	P x P
NRCHB 101 X PM 27	1.99**	A x G
RH 749 X JM 1	1.67**	G x A
Harvest index		
P. Tarak X PM-27	3.21**	P x P
IC-597889 X JM 1	3.03**	A x A
Kranti X JM 1	2.79**	P x A
Oil content		
RH- 30 X JM 1	0.72**	P x A
PM- 30 X CS 54	0.69**	P x G
P. Tarak X JM 1	0.68**	G x A

* and ** represent level of significance at 5 and 1%, respectively

Table 4: Top ranking crosses for seed yield per plant and other characters in Indian mustard

Crosses	*Per se* performance	Specific combining ability effect	General combining ability effect		Other characters with same specific combining ability effect
			P1	P2	
PM- 30 X CS 54	14.28	2.40**	-0.06	-0.34	1000- seed weight and oil content
NRCHB 101 X PM 27	13.07	1.99**	0.26	0.92	Days to 50% flowering and days to maturity
RH 749 X JM 1	14.59	1.67**	1.58	0.05	Days to 50% flowering, no. Secondary branches per plant, no. Of siliqua per plant and 1000-seed weight
IC-597889 X JM-1	9.12	1.67**	-1.28	0.05	Harvest index
RH-30 x CS-54	9.69	1.63**	-0.58	-0.34	Biological yield per plant

for days to 50% flowering and cross combination P. Tarak X EJ 20 exhibited highly significant negative sca effect for days to maturity. These cross combinations can be exploited to isolate early maturing genotype in later generations. Cross combination NRCHB-101 x CS-54 was good specific combiner for plant height, number of secondary branches per plant and no. of siliquae per plant. Cross combination Pusa Mustard-30 x Pusa Mastard-27 was proved to be a good specific combiner for no. of primary branches per plant, no. of secondary branches per plant and number of siliquae per plant. Cross combination PM- 30 x CS 54, NRCHB 101 x PM 27, RH 749 x JM 1, IC-597889 x JM-1 and RH-30 x CS-54 showed significant positive sca effects for seed yield (table-4).

It was observed for most of the characters that there was close association between mean performance and gca effects of the parents. However, combinations having high mean did not exhibit high sca effects for all the characters suggested that only good general combiner on the basis of mean performance may be reliable but not good specific combiner. Parents involved in these crosses were P x P, A x G, G x A, P x A and P x P combiners. The cross combinations involving either both or one parent with high gca effect indicated additive gene action in controlling the expression of respective trait. These cross combinations would give rise to transgressivesegregants in later generations. While cross combinations involving P x P combiners reflected non-additive gene action, which is nonfixable in nature and could be exploited only through heterosis breeding for further improvement of the respective trait. Similar findings were reported by earlier workers Mall *et al*., (2010), Parmar*et al*., (2011), Verma *et al*., (2011) and Kumar *et al*., (2021).

Reference

Akabari VR, Sasidharan N, Kapadiya V. 2017. Combining ability and gene action study for grain yield and its attributing traits in India mustard. *Electronic J Plant Breeding,* **8**: 226-235.

Choudhary P, Sharma H, Sanadya SK, Dodhiya NS, Bishop V. 2020.Combining ability for agronomic and quality traits in Indian mustard. *Int J Chem Studies,* **8**: 720-724.

Kaur G, Kaur M, Kuma R. 2020. Line × Testers analysis for quantitative traits in Indian mustard (*Brassica juncea* L.). *J Oilseed Brassica,* **11**: 77-87.

Kaur S, Kumar R, Kaur R, Singh I, Singh H, Kumar V. 2019. Heterosis and combining ability analysis in Indian mustard (*Brassica juncea*). *J Oilseed Brassica* **10**: 38-46.

Kempthorne O. 1957. An Introduction to General Statistics.John Wiley and Sons.Inc. New York. Chapman and Hall Ltd. London, p. 468-470.

Kumar N, Avatar R and Vivek KS. 2021. Combining ability Analysis mustard in [*Brassica juncea* (L.) Czern & Coss]. *Electronic J Plant Breeding,***12**: 667-672.

Mall AK, Bhajan R, Kumar K and Verma OP. 2010. Combining ability analysis for some metric traits over environments in Indian-mustard [*Brassica juncea* (L.) Czern & Coss]. *Pantnagar J Research,* **8**: 20-25.

Malviya N, Kumar K, Upadhyay DK. 2016. Combining ability and heterosis for seed yield, its component traits and oil content in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. *J Pharmacognosy Phytochemistry,* **8**: 696-699.

Meena HS, Ram B, Kumar A, Singh BK, Meena PD, Singh VV and Singh D. 2014. Heterobeltiosis and standard heterosis for seed yield and important traits in *B. juncea*. *J Oilseed Brassica,* **5**: 134-140.

Parmer SA, Jaimini SN and Ram B. 2011. Combining ability analysis for seed yield and its components over environments in Indian mustard [*Brassica juncea* (L.) Czern & Coss]. *J Oilseed Brassica,* **2**: 61-66.

Pratap P, Meena PD, Singh BK, Meena HS, Meena SS, Sharma P, Majumdar R and Singh D. 2014. Development and evaluation of Alternaria blight tolerant lines in Indian mustard (*B. juncea*). *J Oilseed Brassica,* **5**: 141-148.

Verma OP, Yadav R, Kumar K, Singh R, Maurya KN and Ranjana. 2011. Combining ability and heterosis for seed yield and its components in Indian mustard [*Brassica juncea* (L.) Czern & Coss]. *Plant Archives,* **11**: 863–865.