Annals of Plant and Soil Research 23(3): 356-362 (2021)
https://doi.org/10.47815/apsr.2021.10084

Combining ability analysis for yield and yield components and quality traits in Indian mustard [*Brassica Juncea* L. (Czern & Coss)]

ANIL KUMAR AND Y.P. SINGH

School of Agricultural Sciences and Engg. IFTM University, Lodhipur Rajput Moradabad- 244102 (UP) India
Received: April, 2021: Revised accepted: June, 2021

ABSTRACT

Combining ability analysis was performed in a 10× 10 half dialle cross in Indian mustard genotypes for yield and quality traitsduring 2017-18 and 2018-19 at the agriculture research farm R.B.(PG) college Mudi, Agra and IFTM university,Lodhipur Rajput Moradabad.In this study, 45 F_1 hybrid and their parents were evaluated for 14 quantitative and qualitative traits. The parents used namely, NRCHB -101, DRMR- IJ- 31, Kanti, Urvashi, Pusa mustard- 25 (NPJ-112), Pusa mustard-26 (NPJ-113), Pusa mustard- 27 (EJ-17), CS- 54, RH- 406, RH - 749. The results indicated that both additive and non-additive type of gene actions were responsible in expression of all the 14 characters. Parental genotypes viz., RH -749, RH -406 and CS -54, showed high GCA effects for seed yield per plant and most of the important characters except days to 50% flowering and days to maturity. The other parent'survashi, PM -27, DRMRIJ- 31, NRCHB -101 showed high GCA effects for the remainingtraits. Out of 45 crosses only three crosses RH- 406 × RH -749, PM- 26 × RH -406 and PM -26 × RH -406 had desirable and significant SCA effects with high per se performance for seed yield per plant in $F_{1's}$ generation. The present study indicated that genetic improvement in the Indian mustard would be achieved by using selected promising crosses having significantly high SCA values coupled with high per se performances.

Key words: Combining ability, genetic component, half diallel, Indian mustard.

INTRODUCTION

Indian mustard [*Brassica juncea* L. (Czern & coss)] is an important oilseed crop of the world. Indian mustard is a major oilseed crop of the Indian subcontinent covering more than five million hectares during the winter season. It plays a major role in catering to the edible oil demand of the country. Mustard crops are being cultivated in 53 countries spreading over six continents across the globe. India(14.8%) is having the third-largest share in rapeseed-mustard production in the world next only to China and Canada. In India, the area of mustard is 6.64 Mha with production 8.5 MT and yield 1281 kg/ha in. (Anonymous 2018-19). However, the yield of most oilseeds is less than the world average. On the hand, the demand for edible oils is increasing very rapidly with an increasing population and has been estimated to be 20.20 million tonnes for the year 2020 and 28.40 million tonnes for the year 2030 and 41.6 million tonnes for the year 2050 (Kumar,(2017)**.**

The yield ceiling in the Indian mustard can be brokenby developing high yielding varieties/hybrids through hybridization, which reshufflesthe genes from suitable diverse parents (Monpara *et al.,* 2007). . Evaluation of breeding material for general and specific combining ability for seed yield and yield components are prerequisites in any breeding program aimed for the development of hybrids/varieties.. 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 parents and their cross combinations in order to exploit them in further crop improvement programme. The present study was, therefore, undertaken with a view to estimate general and specific combining ability variances and effects in Indian mustard through diallel approach.

MATERIALS AND METHOD

Ten diverse genotypes viz. NRCHB- 101, DRMR- IJ- 31, Kanti, Urvashi, Pusa mustard- 25 (NPJ-112), Pusa Mustard-26 (NPJ-113), Pusa mustard -27 (EJ-17), CS -54, RH -406, RH- 749 were crossed in half diallel 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 grown in single row of 5 m length with row to row and plant to plant distance of 45 ×15 cm respectively,

Author email - anilsingh2929@gmail.com

during rabi season (post rainy) 2017-18 at research farm, School of Agricultural and Engg. IFTM University, Lodhipur Rajput, Moradabad (U.P.) and during *rabi* season in the year of 2018-19 to 2019-20 at the agriculture research farm R.B. (PG) College, Mudi, Agra. Recommended cultural practices were adopted in order to raise a healthy crop. A sample of five plants were selected randomly for recording the observations on various parameters *i.e.*days to 50% flowering, days to maturity, plant height, primary branches per plants, secondary branches per plant, main shoot length (cm), number of siliquae on main shoot, number of siliquae per plant, siliqua length (cm), number of seeds per siliqua, 1000-seed weight (g), oil content (%), fiber content (%) and seed yield per plant (g).Mean values of sample for various traits were subjected to combining ability analysis method II model I of Griffing, (1956).

RESULTS AND DISCUSSION

The analysis of combining ability revealed considerable genetic diversity among the parents, cross combinations as well as between parental group and cross combination group for all the characters. The Table **1** showed that mean sum of squares due to both general and specific combining ability were significant for all the characters suggesting importance of both additive and non-additive gene effects in the inheritance of these characters. The estimates of gca/scaratio was higher for all thetraits except days to 50% flowering, primary branches/plant, main shoot length (cm), siliquae on main shoot and number of siliquae/plant. The higher values of ratio was recorded for siliqua length (cm), seed yield per plant (g), plant height, fiber content, secondary branches per plant, oil content. Dominant and recessive alleles of number of siliquae per plant, length of siliqua, 1000 seed weight, oil content fiber content and seed yield per plant were symmetrically distributed among the parents. Similar findings and their implication of these results in Indian mustard breeding has been discussed byTuri *et al.*, (2011) and Dar *et al.,* (2012).

General combining ability

A perusal of general combining ability (gca) effects of parents indicated that RH- 406, RH - 749 and CS- 54 found to be good general combiner for seed yield per plant and most of the other traits as well (Table 2).

Table 1: Analysis of variance of combing ability

Source of variation	GCA	SCA	Error	gca/sca raio
D.F.	9	45	108	
Days to 50% flowering	4.58*	8.89**	2.40	0.52
Days to maturity	124.19**	96.76**	2.80	1.28
Plant height (cm)	1149.63**	539.99**	0.82	2.13
Pri. Branches/plant	1.75**	3.21**	0.21	0.55
Sr. Branches/ plant	134.81**	99.29**	0.19	1.36
Main shoot length (cm)	145.28**	323.45**	0.77	0.45
Siliquae on main shoot	163.26**	191.15**	2.26	0.85
No of siliquae/ plant	143262.45**	194939.10**	673.10	0.73
Siliquae length (cm)	1.87**	0.31**	0.02	6.07
Seeds per siliquae	3.43**	4.93**	0.19	0.70
1000 seed weight (g)	0.99**	0.81**	0.00	1.22
Oil content (%)	0.59**	0.49**	0.07	1.21
Fiber content (%)	1.03**	0.62**	0.03	1.65
Seed yield per plant (g)	334.15**	101.20**	1.88	3.30

On the other hand parents NRCHB -101, DRMRIJ -31, Kanti, Pusa mustard -25 and Pusa mustard- 26 showed highly significant negative *gca* effects. For the yield components such as secondary branches per plant, line CS -54, PM - 26 and PM -27 were appeared to be good general combiner. Similarly, for main shoot length, the DRMRIJ -31, Kanti, Urvashi, RH 406 and PM 27, for number of siliquae on main shoot, the DRMRIJ -31 and Urvashi, number of siliquae per plant, RH -749, CS -54, RH- 406, Pusa mustard -27 (PM- 27) and DRMRIJ -31, length of siliqua, RH -749, NRCHB -101, PM -25, PM -27 and DRMRIJ -31, number of seeds per siliqua, DRMRIJ -31, RH -406, Pusa Mustard -27, PM -25 and Urvashi were found to be the best combiners. In case of 1000 seed weight NRCHB 101, RH- 406, DRMRIJ -31, CS -54 and Pusa mustard 27 (PM- 27) were good general combiner. For days to 50% flowering, parents showing negative and significant values were identified as good general combiner's viz. PM -27, in case of days to maturity, PM-27, PM -25, PM -26 and CS- 54 also having negative *gca* effect and identified as good general combiners. The parents RH 406, Urvashi, RH -749, CS- 54 and NRCHB -101 were the best combiners for plant height**.** For oil content and sugar content the DRMRIJ -31, PM -26 and RH -749 and for fiber content the PM -26, PM -25, RH -406, CS -54 found to have positive gca effects and identified to be as good combiners. Based on these observations, it can be concluded that parent RH 406, RH 749 and CS 54, possess desirable alleles for most of the characters. Hence, these parents could be used in future breeding programme for improvement of respective characters and for formation of new heterotic groups. Out of 45 crosses only six crosses viz; PM 26 × CS 54, RH 406 × RH 749, KANTI × PM 25, NRCHB101 × DRMRIJ 31, PM 26 × RH 406 and PM 27 ×CS 54 crosses showed significant positive effect for seed yield and other characters (Table 2). This new group of crosses indicated possibility in the development of commercial hybrids in Indian mustard in order to exploit hybrid vigour at commercial level. These results are in agreement with earlier findings of Lal *et al.,* (2011), Chaurasiya*et al.,* (2018) and Singh *et al.,* (2019).

Specific combing ability (sca)

A perusal of the data presenting in (Table 3) for specific combining ability indicated that none of the cross combination was found to be a common specific combiner for all the characters under study. The cross Kanti × Urvashi , NRCHB -101 × RH -749, PM -27 × CS 54, DRMRIJ -31 × RH- 406 and NRCHB 101 × CS-54 had significant and negative *sca* effects and are considered as best specific combiners for days to 50% flowering. For early maturity, crosses Kanti× Urvashi, PM -27 × RH -406, UrvashI × CS -54, Kanti × PM -25, RH- 406 × RH -749 and DRMRIJ -31 × RH 749 had the negative and high significant *sca* effect and identified as good specific combiner while parental lines RH -749, NRCHB -101 and DRMRIJ -31 had highly positive significant *gca* effects for days to maturity.

The hybrids Kanti× PM -25, DRMRIJ -31× PM 27, DRMRIJ -31 × Urvashi, NRCHB-101 X Pusa Mustard 27 had showed positive and significant values of sca effects for taller plants. For yield combining traits number of siliquae on main shoot identified Kanti× PM 26, DRMRIJ 31 × Urvashi, PM 26 × PM 27, Kanti× PM 25 and Urvashi× PM 25 crosses for more number of pods per plant. The traits number of siliquae per plant RH 406 X RH 749, PM 26 X CS 54, Kanti× PM 25, DRMRIJ 31 × Urvashi and PM -27 × CS -54 crosses had positive and significant sca effects and find best specific combiner for more siliquae per plant. The hybrids Urvashi× PM -27, PM-27 × RH -749, NRCHB -101× NPJ -112(PM-25), Kanti× Urvashi, find best specific combiners for longest siliqua. The DRMRIJ 31 × RH 406, Urvashi× PM 27, PM 25 × PM- 26, NRCHB -101 × Kanti, NRCHB-101 × DRMRIJ -31 and DRMRIJ -31 × CS- 54 identified for more number of seeds per siliqua. The best specific combiner for 1000 seed weight were Kanti× RH -406, DRMRIJ -31 × RH -406, PM -25 × RH-749, PM 26 × PM -27, DRMRIJ -31 × PM- 27 and DRMRIJ -31 ×PM -26.The hybrids i.e. DRMRIJ 31 × Urvashi, Urvashi× PM -25, PM -26 ×CS 54, Kanti× CS -54, PM -26 ×RH 406 and PM -25 × PM -27 were found for best specific combiner for oil content, while fiber content, crosses PM 25 × PM 26, PM -27 × RH 406, PM -26 × RH -406, DRMRIJ -31 ×RH 749, NRCHB-101×DRMRIJ 31 and PM -25 × RH -749 had positive and significant sca values for more fiber content.The best cross combinations for seed yield per plant were PM 26 X CS 54, RH 406 X RH 749, Kanti X PM 25, NRCHB-101 × DRMRIJ -31, PM 26 × RH -406 and PM 27 × CS -54. It is interesting to note that the parental lines viz., NRCHB -101, DRMRIJ -31, Pusa mustard -25 and Kanti having negative significant value exhibited positive *sca* effects in combination with RH -406 and CS -54. .

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

Table 2: GCA effects for parents of Indian mustards

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches/ plant	Secondary branches/ plant	Main shoot length (cm)	Number of siliquae on main shoot	No. of siliquae/ plant	Siliquae length (cm)	Seeds per siliquae	1000 seed weight (g)	Oil content (%)	Fiber content (%)	Seed yield per plant (g)
NRCHB 101	0.70	4.14**	0.76**	-0.08	-1.33**	-1.94**	0.13	-104.69**	0.33**	-0.36**	0.38**	-0.21**	0.07	-4.46**
DRMRIJ 31	0.14	1.64**	-2.02**	0.11	-4.97**	4.17**	8.02**	13.23	0.14**	0.67**	0.32**	0.29**	-0.35**	-3.55**
Kanti	-0.38	0.28	-4.74**	-0.36**	-1.77**	2.92**	0.33	-83.99**	-0.28**	-0.11	-0.16**	0.08	-0.51**	-2.51**
Urvashi	-0.58	0.39	9.65**	0.06	-0.55**	2.78**	3.36**	-103.27**	-0.75**	0.36**	-0.34**	-0.07	-0.08	-0.57
Pusa Mustard 25 (PM 25)	-0.05	-4.63**	-8.63**	-0.33**	-0.77**	-4.97**	-5.20**	-137.83**	0.30**	0.36**	-0.31**	-0.32**	0.27**	-6.42**
Pusa Mustard 26 (PM 26)	-0.33	-0.97*	-14.27**	-0.56**	5.26**	-6.25**	-3.51**	-15.55*	-0.29**	-0.86**	-0.29**	0.25**	0.42**	-2.73**
Pusa Mustard 27 (PM 27)	-0.94**	-5.22**	-11.35**	0.72**	1.34**	0.78**	-2.51**	14.98*	0.18**	0.25*	0.08**	0.07	-0.21**	-0.03
CS 54	-0.22	-1.11**	7.37**	0.11	6.01**	-0.39	-1.01**	140.78**	-0.11**	-0.86**	0.13**	-0.31**	0.21**	3.79**
RH 406	0.98*	0.81	13.98**	-0.11	-1.63**	2.64**	0.27	114.45**	-0.13**	0.39**	0.35**	0.03	0.22**	10.76**
RH 749	0.67	4.64**	9.23**	0.44**	-1.58**	0.28	0.11	161.89**	0.62**	0.17	-0.16**	0.18*	-0.05	5.73**
SE (gi)	0.42	0.46	0.25	0.13	0.12	0.24	0.41	7.10	0.04	0.12	0.01	0.07	0.05	0.38
SE (gi-gj)	0.63	0.68	0.37	0.19	0.18	0.36	0.61	10.59	0.06	0.18	0.02	0.10	0.08	0.56

Table 3: Best five sca effects for hybrids of Indian mustards

Characters	Best sca hybrids	sca	Characters	Best sca hybrids	sca	Characters	Best sca hybrids	sca
Days to 50% floweing	KANTI X URVASHI	-9.88	Main shoot length (cm)	URVASHI X PM 25	30.07	1000 S.W.	KANTI X RH 406	2.00
	NRCHB 101XRH 749	-7.22		NRCHB 101XKANTI	26.57		DRMRIJ 31XRH 406	1.85
	PM 27 X CS 54	-3.69		KANTI X CS 54	25.02		PM 25 X RH 749	1.85
	DRMRIJ 31XRH 406	-3.63		DRMRIJ 31XURVASHI	22.27		PM 26 X PM 27	1.30
	NRCHB 101XCS-54	-3.33		KANTI X PM 26	20.88		DRMRIJ 31XPM 27	1.03
Plant height (cm)	KANTI X URVASHI	-17.46	Siliquae on main shoot	KANTI X PM 26	23.50	Oil %	DRMRIJ 31XURVASHI	1.09
	PM 27 X RH 406	-14.04		DRMRIJ 31XURVASHI	20.62		URVASHI X PM 25	0.99
	URVASHI XCS 54	-12.07		PM 26 X PM 27	20.01		PM 26 X CS 54	0.98
	KANTI X PM 25	-10.77		KANTI X PM 25	19.20		KANTI X CS 54	0.88
	RH 406 X RH 749	-10.57		URVASHI X PM 25	18.17		PM 26 X RH 406	0.81
Days to maturity	KANTI X PM 25	47.80	No of siliquae/plant	RH 406 X RH 749	1411.60	Fiber	PM 25 X PM 26	1.34
	DRMRIJ 31XPM 27	33.14		PM 26 X CS 54	959.05		PM 27 X RH 406	1.10
	DRMRIJ 31XURVASHI	31.80		KANTI X PM 25	875.10		PM 26 X RH 406	1.09
	NRCHB 101XPUSA MUSTARD 27	29.36		DRMRIJ 31XURVASHI	866.66		DRMRIJ 31XRH 749	1.00
	KANTI X PM 26	28.44		PM 27 X CS 54	790.85		NRCHB101XDRMRIJ 31	0.91
Pri. Braches/plant	PM 25 X RH 749	4.31	Siliquae length (cm)	URVASHI X PM 27	1.21	Seed yield per plant (g)	PM 26 X CS 54	26.76
	PM 27 X CS 54	3.92		PM 27 X RH 749	1.00		RH 406 X RH 749	26.37
	PM 27 X RH 406	3.81		NRCHB 101XPM25	1.00		KANTI X PM 25	13.08
	KANTI X PM 25	2.45		KANTI X URVASHI	0.67		NRCHB101XDRMRIJ 31	12.94
	PM 26 X RH 406	2.42		DRMRIJ 31XCS 54	0.61		PM 26 X RH 406	11.36
Sr. Branches/plant	RH 406 X RH 749	28.76	Seeds per siliquae	DRMRIJ 31XRH 406	4.19			
	PM 26 X CS 54	25.96		URVASHI X PM 27	3.96			
	PM 25 X PM 26	20.07		PM 25 X PM 26	3.74			
	NRCHB 101XPM 27	17.54		NRCHB 101XKANTI	3.38			
	PM 27 X CS 54	12.21		NRCHB101XDRMRIJ 31	2.94			

mean did not exhibit high sca effects for all the characters suggesting 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 H×H, H×L, L× H and L× L 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 transgressive segregants in later generations. While cross combinations involving L x L combiners reflected non-additive gene action, which is non-fixable in nature and could be exploited only through heterosis breeding for further improvement of the respective trait. Similar findings were reported by earlier workers Lal *et al.,* (2011), Pardeep *et al.,*(2013), Shrimali *et al.,* (2016) Chaurasiya *et al.,* (2018) and Singh *et al.,* (2019).

Components of genetic variance

The ratio of $(H_1/D)½$ was indicating the average additive dominance relationship for days to 50% flowering. The ratio of $H_2/4H_1$ was near to 0.18 for days to 50% flowering, days to maturity, Number of primary branches/ plant, hence, it may be concluded that the positive and negative alleles were distributed symmetrically among the parents. It is apparent that the variation observed in plant height is determined by additive and dominance components of genotypic variance. Dominance variance exceeded the additive genetic variance and the degree of dominance was found to be in over dominance range. The ratio of $H_2/4H_1$ did not deviate much from 0.25, hence, it may be concluded that increasing and decreasing alleles were distributed symmetrically among the parents for most of the characters. The variation observed in this trait was governed by dominance variance and average degree of dominance was in the over dominance range. The higher narrow sense heritability among the parents showing both increasing and decreasing were distributed symmetrically. Dominant alleles showed equal positive and negative effects. The ratio of $(H_1/D)½$ for seed yield per plant (g)showed the average additive dominance relationship and the ratio of $H_2/4H_1$ was 0.22 indicating that the positive and negative alleles were distributed symmetrically among the parents. The narrow sense heritability was low (13.99%). The correlation between parental mean and parental order of dominance was positive and significant showed that the dominant genes contributed equally positive effects in the parental lines.

The results of the study revealed that non- additive genetic variance play a predominant role in the inheritance of the traits. The best combination mostly involved high × low general combinations for the characters under study. On the basis of gca and sca effects, three parents i.e. RH-749, RH-406 and CS-54 showed high gca effects for seed yield per plant, and the five superior cross combinations PM-26 × CS-54, RH -406× RH-749, Kanti × PM-25, NRCHB-101 × DRMRIJ-31 and PM-26 × RH-406 were found good specific combiners for seed yield per plant and also for some other yield contributing traits. These crosses may be used in heterosis breeding programme for developing new hybrids with better yield and quality. For higher genetic improvement in the Indian mustard, the systematic breeding program should include promising crosses having significant high SCA values as well as high per se performance. Such promising combinations are expected to produce desirable transgressive segregants to achieve high yield and quality (meaning not clear, so deleted).

REFERENCES

Anonymous. (2018-19). Data of Rapeseed and Mustard; *Website: www.nmoop.gov.in*

Chaurasiya, Jagdish Prasad, Mahak Singh, RK Yadav and Lokendra Singh (2018). Heterosis and combining ability analysis in Indian mustard (*Brassica juncea* (L.) Czern and Coss.). *Journal of Pharmacognosy and Phytochemistry* **18**; 7(2): 604-609.

Dar, Z.A., Wani, S.A., Gulzaffar and Habib, M. (2012). Genetic studies in brown Sarson (*Brassica rapa* L.). *Trends in Biosciences*, **5** (4): 317-320.

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, Arvind (2017). Proceeding of 3rd national brassica conference held at IARI New Delhi on dated 2017; **16**-18:7.

Lal, M., Singh, D.P. and Bagadi, D.L. (2011). Combining ability analysis for seed yield and its components in Indian mustard [*Brassica juncea* (L.) Czern & Coss]. *Agricultural Science Digest*, **31** (1): 35 – 37.

Montara, B.A. and Dobariya, K.L. 2007. Heterosis and combining ability in Indian ustard Brassica juncea (L.) Czern & Coss]. *Journal of Oilseeds Research*., ***24***(2): 306-308.

Pardeep Kumar, Alankar Lamba, R. K. Yadav, Lokendra Singh and Mahak Singh (2013). Analysis of yield and its components based on heterosis And combining ability in indian mustard (*Brassica Juncea* Czern & coss). *The Bioscan,* **8**(4): 1497-1502, 2013 (Supplement on Genetics & Plant Breeding)

Shrimali, T. M. R. M. Chauhan, K. P. Prajapati*, S. A. Desai, J. R. Patel, P. T. Patel, P. J. Patel, and Bharat K. Chaudhary (2018). Analysis of Yield and Its Components Based on Heterosis and Combining Ability in Indian mustard (*Brassica juncea* L. Czern & Coss.). *International Journal of Pure Applied Bioscience.* **6** (1): 219-224.

Singh, H., Ravindra Kumar Satveer Kaur, Ikbal Singh and Ramandeep Kaur (2019). Genetic Analysis of Indian mustard for Yield by Calculating Heterosis and Combining Ability. *Journal of Agriculture Science*, **10**(1-2): 1-12.

Turi, N.A., Raziuddin, Farhtullah, Khan, N.U., Iqbalmunir, Shah, A.H., Khan, S. Ghulam, H., Jehan, B., Sajid, K. and Mohammad, S. (2011). Combining ability for yield related traits in [Brassica juncea. (L.) Czern & Coss. *Pakistan Journal of Botany*. **43** (2): 1241-1248.