Original Research Article   https://doi.org/10.20546/ijcmas.2017.610.139

Heterosis Analysis for Seed Yield and Other Component Traits in Indian Mustard [*Brassica juncea* (L.) Czern and Coss]

Sneha Adhikari[*], Sanjana Pathak, Deepak Joshi, Usha Pant, A.K. Singh and Ram Bhajan

Department of Genetics and Plant Breeding, G. B. P. U. A. & T. Pantnagar, U. S. Nagar, Uttarakhand-263145, India
*Corresponding author

A B S T R A C T

Ten diverse Indian mustard (*Brassica juncea* L. Czern and Coss) genotypes suitable for early, timely and late sown condition were crossed in diallel mating design excluding reciprocals with an objective to identify the heterotic crosses. All three type of heterosis (relative heterosis, heterobeltiosis and economic heterosis) were estimated for seed yield and contributing traits. The results indicated presence of significantly high heterosis in desirable direction for all the characters except plant height and glucosinolate content. RRN-778×Maya, RRN-778×Maya and RB-57×Maya for early maturity, Maya×RMM-09-4, RB-57×PM-25 and PRL-2012-13xDRMR-675-39 for seed yield, PRL-2012-13×RRN-778, PRL-2012-13×RRN-778 and DRMR-675-39×Maya for oil content were most promising heterotic crosses for mid parent heterosis, better parent heterosis and economic heterosis respectively whereas, for plant height Divya-55×Maya was found most promising cross for mid parent heterosis.

Introduction

Indian mustard [*Brassica juncea* L. (Czern & coss)] is an important oil seed crop of the world. It plays a major role in catering edible oil demand of the country. Indian mustard (*Brassica juncea*) is a major oilseed crop of the Indian subcontinent covering more than five million hectares during the winter season. It is also grown in Australia, China, CIS and Canada. Indian mustard is a predominantly self-fertilized crop with 5-15 per cent cross-fertilization. The oil content of mustard varies between 28.6 to 45.7 per cent. Oils and fats are essential components of our daily diet and also a major source of raw material for a wide range of products required in our life. Oil extracted from the seeds of these crops is used

for cooking, frying, spice, for seasoning of the food articles, vegetables and industrial purposes.

Population of India is increasing rapidly and consequently edible oil demand is also going up day-by-day. Hence, it has become necessary to increase the production by developing superior varieties. In the past most of the varieties were developed through selection that lead to the narrow genetic base and low level of diversity in the gene pool. Low diversity and same parentage cause stagnation in the yield potential of crop. The yield ceiling can be break by developing varieties through hybridization which is the

result of reshuffling the genes through from suitable diverse parents. Heterosis breeding in crop plants has been the most successful approach among various technical options available to the geneticists and plant breeders for improvement productivity of crop plants. Heterosis in mustard has been recognized as a means of improving yield and other important traits therefore, it could be a potential alternative for substantially increasing the production of Indian mustard. Successful exploitation of heterosis would depend upon the identification of hybrids that are more productive than either of the parents and standard check cultivars. In oilseed Brassicas heterosis was first reported in brown sarson by Singh and Mehta (1954). Subsequently many studies have reported the extent of heterosis for seed yield. Significant level of heterosis was reported in *B. juncea* (13 to 91%) by Verma *et al.,* (2011), Yadava *et al.,* (2012) and Meena *et al.,* (2015). It was also observed that hybrids between genetically distant groups showed greater heterosis than within the group combinations. Significant levels of heterosis for yield contributing parameters have also been reported.

Materials and Methods

The experimental material for present study comprised of 10 diverse genotypes of Indian mustard (*Brassica juncea* L.) involving two genotypes suitable for early sown (PRE-2011-15, PM-2), six for timely sown (Divya-55, Maya, DRMR-675-39, RRN-778, RB-57 and RMM-09-4) and two for late sown (PRL-2012-13, NRC-HB-101) situations. The list of genotypes along with the pedigree are given in table 1.

The parents were crossed in diallel mating design excluding reciprocals (half diallel) during rabi season 2014-15. Ten parents and 45 F_1's were evaluated in a randomized block design with three replications during rabi

2015-16. All 55 treatments were evaluated for 13 characters *viz.,* Days to flowering Days to maturity, Plant height (cm), Length of main raceme (cm), Number of siliquae on main raceme, Siliqua density, Number of primary branches per plant, Number of secondary branches per plant, Siliqua length (cm), Number of Seeds per siliqua, Seed yield per plant (g), Test weight (g), Oil content (%) and Glucosinolate content (µmole/g fat free meal). Five randomly selected competitive plants for each plot were used for recording observations. Days to 50% flowering and days to maturity were recorded on plot basis. The experimental data recorded for various characters were analyzed as per the procedure of Panse and Sukhatme (1978) and heterosis was calculated following the method of Fonseca and Patterson (1968).

Results and Discussion

All three type of heterosis (relative, heterobeltiosis and economic heterosis) were observed significant in desirable direction for all the characters except plant height and glucosinolate content where the estimate of heterosis was numerically high but non-significant.

The evaluation of heterosis (Table 2) revealed that crosses Divya-55×PM-25 (-24.324**), PRL-2012-13×PRE-2011-15 (-27.27**), NRCHB-101×PRE-2011-15 (-12.50**) for days to flowering (Yadav *et al.,* 1974), RRN-778×Maya (-5.660*), RRN-778×Maya (-7.41**), RB-57×Maya (-20.741**) for early maturity (Ahsan *et al.,* 2013), NRCHB-101×Divya-55 (17.44**), RMM-09-4×PM-25 (21.12**), DRMR-675-39×RMM-09-4 (49.45**) for length of main raceme, PRE-2011-15×RMM-09-4 (6.85**), NRCHB-101×Maya (17.51**), DRMR-675-39×RMM-09-4 (159.67**) for number of siliquae on main raceme, PRE-2011-15×RMM-09-4 (13.97**), PRL-2012-13 × DRMR-675-39

(29.18**), DRMR-675-39 × RMM-09-4 (66.38**) for siliqua density, NRCHB-101 × Divya-55 (16.98**), NRCHB-101 × Divya-55 (24.00**), Divya-55 × RMM-09-4 (66.78**) for number of primary branches per plant (Monpara *et al.,* 2007), RB-57×Maya (32.04**), RB-57 × Maya (41.67**), PRL-2012-13 × DRMR-675-39 (128.45**) for number of secondary branches per plant (Katiyar *et al.,* 2000), RB-57 × PM-25 (17.07**), RB-57×PM-25 (20.00**), PRE-2011-15×PM-25 (15.63**) for siliqua length, DRMR-675-39×Maya (15.52**), PRL-2012-13× RB-57 (26.79**), PRE-2011-15×PM-25 (264.03**) for number of seeds per siliqua, NRCHB-101×Divya-55 (4.69**), PRE-2011-15×RMM-09-4 (5.56**), RRN-778×RMM-09-4 (85.35**) for test weight, Maya×RMM-09-4 (24.48**), RB-57×PM-25 (43.64**) and PRL-2012-13xDRMR-675-39 (142.57**) for seed yield (Kumar *et al.,*2014), PRL-2012-13×RRN-778 (3.22**), PRL-2012-13×RRN-778 (3.58**) and DRMR-675-39×Maya (6.28**) for oil content were most promising heterotic crosses for mid parent heterosis, better parent and economic heterosis respectively whereas, for plant height none of the cross combination exhibited significant relative, heterobeltiosis and economic heterosis whereas Divya-55×Maya (-11.42) was most promising cross for mid parent heterosis. None of the cross combination exhibited significant heterosis in desirable direction i.e. for low glucosinolate while some crosses PRE-2011-15×Maya (-1.51), DRMR-675-39×PRE-2011-15 (-1.44), NRCHB-101×PRE-2011-15 (-1.41), and PRL-2012-13×PM-25 (-1.40) possess negative estimate of heterosis for low glucosinolate content. Moderate to high heterosis was also reported by Bhatt *et al.,* (2005) Meena *et al.,* (2015), Kumar *et al.,* (2016).

Table.1 List of genotypes along with the pedigree

S. No.	Name of the line	Pe pedigree	Features
1.	PRL-2012-13	BBM-06-02×Ashirwad	Late sown
2.	NRC-HB-101	BL-4×Pusa Bold	Late sown
3.	Divya-55	Divya-22 × Laxmi	Timely sown
4.	DRMR-675-39	PCR-20×Sej	Timely sown
5.	PRE-2011-15	(PRB-2004-6×PR-2002-20)×NDRE-4	Early sown
6.	RRN-778	Protogynous Varuna × RRN 601	Timely sown
7.	RB-57	Laxmi×CS-52	Timely sown
8.	RMM-09-04	Rohini×Maya	Timely sown
9.	Maya	Varuna×KRV-11	Timely sown
10.	PM-25	Sej-8×Pusa Jaganath	Early sown

Table.2 Top three relative heterotic, heterobeltiotic and heterotic cross for earliness and other yield parameters

C	Crosses	RH	CD		Crosses	HB	CD		Crosses	H	CD
DM	RRN-778×Maya	-5.660*	5.769	4.389	RRN-778×Maya	-7.41**	6.661	5.068	RB-57×Maya	-20.741**	6.661	5.068
	PRL-2-12-13× RMM-09-4	-4.000			PRE-2011- 15×RB-57	-5.19*			NRCHB-101×PRE-2011-15	-20.000**		
	PRE-2011-15× Maya	-3.475			DRMR-675-39 ×PM-25	-4.17			Maya×PM-25	-18.519**		
PH	Divya-55×Maya	-11.42	23.481	17.866	Divya-55× Maya	-11.42	27.114	20.630			27.114	20.630
	PRE-2011-15×RB-57	-10.25			PRE-2011-15 ×RB-57	-10.25						
	PRL-2012-13×Maya	-8.55			PRL-2012-13× Maya	-8.55						
PB	NRCHB-101×Divya-55	16.98**	0.742	0.565	NRCHB-101×Divya-55	24.00**	0.857	0.652	Divya-55×RMM-09-4	66.78**	0.857	0.652
	DRMR-675-39×RB-57	16.98**			DRMR-675-39×Maya	24.00**			Divya-55×PRE-2011-15	31.54**		
	DRMR-675-39×Maya	16.98**			DRMR-675-39×RB-57	24.00**			Divya-55×Maya	31.54**		
SL	RB-57×PM-25	17.07**	0.515	0.392	RB-57×PM-25	20.00**	0.595	0.453	PRE-2011-15×PM-25	15.63**	0.595	0.453
	PRE-2011-15×RMM-09-4	16.08**			NRCHB-101×RRN-778	19.51**			PRE-2011-15×RRN-778	13.49**		
	NRCHB-101×RRN-778	11.62**			PRE-2011-15×RMM-09-4	19.14**			Divya-55×PM-25	11.35**		
S/S	DRMR-675-39×Maya	15.52**	2.132	1.622	PRL-2012-13× RB-57	26.79**	2.462	1.873	PRE-2011-15×PM-25	264.03**	2.462	1.873
	PRL-2012-13× RB-57	15.45**			DRMR-675-39×Maya	19.64**			PRE-2011-15×RMM-09-4	242.61**		
	Divya-55×PM-25	10.00**			PRL-2012-13×NRCHB-101	15.00**			Divya-55×RMM-09-4	242.18**		
SYP	Maya×RMM-09-4	24.48**	1.469	1.117	RB-57×PM-25	43.64**	1.696	1.290	PRL-2012-13xDRMR-675-39	142.57**	1.696	1.290
	PRL-2012-13×RRN-778	21.65**			Maya×RMM-09-4	40.94**			Divya-55×RMM-09-4	110.40**		
	RMM-09-4×PM-25	19.65**			PRL-2012-13×RRN-778	36.82**			PRL-2012-13×Divya-55	109.57**		
TW	NRCHB-101×Divya-55	4.69**	0.208	0.158	PRE-2011-15×RMM-09-4	5.56**	0.240	0.182	RRN-778×RMM-09-4	85.35**	0.240	0.182
	RRN-778×PM-25	4.00**			NRCHB-101×Divya-55	4.69**			PRL-2012-13×RMM-09-4	76.33**		
	PRE-2011-15×RMM-09-4	3.95**			PRL-2012-13×RMM-09-4	4.65**			Divya-55×DRMR-675-39	68.10**		

C= Characters, DF= Days to flowering, DM= Days to maturity, PH= Plant height, LMR= Length of main raceme, SMR= Siliqua on main raceme, SD= Siliqua density, PB= No. of primary branches per plant, SB= No. of secondary branches per plant, SL= Siliqua length, S/S= Seeds per siliqua, SYP= Seed yield per plant, TW= Test weight

Table.3 Best three heterotic and heterobeltiotic crosses (F_1) for seed yield/plant along with their SCA effects and per se performance

Heterotic crosses	Heterosis	SCA effect	Per se performance	Heterobeltiotic crosses	Heterosis	SCA effect	Per se performance
PRL-2012-13×Divya-55	109.57**	3.72**	14.31	Divya-55× PRE-2011-15	24.96**	1.76**	10.10
PRL-2012-13×NRCHB-101	68.32**	2.83**	12.92	NRCHB-101× RMM-09-4	7.19**	3.52**	10.74
NRCHB-101 ×RMM-09-4	42.74**	3.52**	10.74	RRN-778× PM-25	5.95**	2.08**	8.51

As reflected in table 3 the significantly heterotic crosses for seed yield also showed substantial and significant SCA effects and high per se performance. Dixit *et al.,* (2005) reported that these crosses showing heterosis and heterobeltiosis for seed yield per plant possessed significant and positive SCA effects. Similar results of significant correlation between heterosis for seed yield and mean performance of the crosses were reported by Ramech (2012) and Aher *et al.,* (2009) found that the promising hybrid also had high per se performance and significant desirable SCA effects for various characters. From data of heterosis and heterobeltiosis, it was observed that crosses with high magnitude of heterosis had higher magnitude of SCA effects and better per se performance. Hence selection of superior crosses for development of hybrids should necessarily base not only on the magnitude of heterosis, but also high mean performance and high SCA effects. Significant heterosis for seed yield was the result of combined effect of other contributing traits therefore; the selection of high yielding genotypes should be based on multiple characters rather than a single character. Estimates of heterotic responses further showed the perceptible advantage of heterozygosity in improving the seed yield. This phenomenon led to identify heterosis breeding as the key methodology for improving genetic yield ceiling in Indian mustard.

References

Aher, C.D., Shelke, L.T., Chinchane, V.N., Borgaonkar, S.B. and Gaikwad, A.R. 2009. Heterosis for yield and yield components in Indian mustard [*Brassica juncea* (L.) Czern and Coss.]. *Int. J. Plant Sci.,* 4: 30–32.

Ahsan, M. Z., Khan, F. A., Kang, S. A. and Rasheed, K. 2013. Combining ability and heterosis analysis for seed yield and yield components in *Brassica napus*. *J. Bio., Agri. and Healthcare,* 3(9) :31-36.

Bhatt, U., Singh, S.P. and Singh, Basudeo 2005. Heterotic response for important traits in *Brassica juncea* (L.) Czern & Coss. *Agric. & Biol. Res.,* 21(2) 169-172.

Dixit, S., Kumar, K. and Chauhan, Y.S. 2005. Heterosis in Indian mustard (*Brassica juncea* L. Czern & Coss). *Agri. Sci. Digest*, 25(1): 19-22.

Fonseca, S., and Patterson, F. 1968.Hybrid vigour in a seven parent diallel cross in common wheat crop. *Crop. Sci*., (1):85-88.

Katiyar, R. K., Chamola, R. and Chopra, V. L. 2000. Heterosis and combining ability in Indian mustard (*B. junca*). *Indian J. Genet.*, 60 (4): 557-559.

Kumar, A., Tiwari, R. and Kumar, K. 2014. Exploitation of heterosis using cytoplasmic male sterility system in Indian mustard (*B. juncea*). *The Ecoscan,* 6: 163-167.

Kumar, Vineet, Pant, D. P., and Pant, Usha 2016. Combining ability and heterosis for seed yield and its component in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. *Environment and Ecology,* 34 (3B): 1382-1388.

Meena, H. S., Kumar, A., Ram, B., Singh, V. V., Meena, P. D., Singh, B. K. and Singh, D. 2015. Combining ability and heterosis for seed yield and its components in Indian mustard [*Brassica juncea* (L.)]. *J. Agr. Sci. Tech.*, 17:1861-1871.

Meena, J., Harsha, Pant, U. and Bhajan, R. Dec 2015. Heterosis analysis for yield and yield attributing traits in Indian mustard (*Brassica juncea* (L.) Czern & Coss. *Electronic J. of Plant Breeding,* 6(4) 1103-1107.

Monpara, B. A., and Dobariya, K. L. 2007. Heterosis and combining ability in Indian mustard. *J. Oilseeds Res.,* 24 (2):

306-308.

Panse, V. G., and Shukhatme, P.V. 1967. Statistical Method for Agricultural Workers, ICAR, New Delhi..235-247.

Rameeh, 2012. Study on combining ability and heterobeltiosis of agronomic traits in spring type of rapeseed varieties using line x tester analysis. *J. Oilseed Brassica*, 3(1): 45-50.

Singh, D., and Mehta, R. 1954. Studies on breeding brown sarson. I. Comparison of F1's and their parents. *Indian J. Genet. Pl. Breed,* 14: 74 -77.

Verma, O. P., Yadav, R., Kumar, K., Singh, R., Maurya, K. N. and Ranjana 2011. Combining ability and heterosis for seed yield and its components in Indian mustard (*Brassica juncea*). *Plant Archiv,* 11:863-865.

Yadav, T. P., Singh, H., Gupta, V.P. and Rana, R.K. 1974. Heterosis and combining ability in raya [*Brassica juncea* (L.) Czern and Coss.] For yield and its components. *Indian J. Genet.,* 34A: 484-485.

Yadava, D. K., Singh, N., Vasudev, S., Singh, S., Giri, S. C., Dwivedi, V. K. and Prabhu, K. V. 2012. Combining ability and heterobeltiosis for yield and yield contributing traits in Indian mustard (*Brssica juncea*). *Indian J. Agri. Sci.*, 82(7): 563-567.