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Heterosis studies based upon *Mori* CMS system in *Brassica juncea* L

Raju Ram Choudhary*, RK Sheoran, Ram Avtar, Deepak Kumar and Samita

Chaudhary Charan Singh Haryana Agricultural University, Hisar-125 004, Haryana, India
**Corresponding author: rajuramchoudhary33@gmail.com*
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Abstract

In present study Line x tester analysis was carried out to estimate all three types of heterosis (relative heterosis, heterobeltiosis and economic heterosis) for identification of superior cross combinations of Indian mustard [*Brassica juncea* (L.) Czern. & Coss.]. Fifty hybrids along with 10 Mori CMS lines, 5 testers and check DMH-1 planted at Oilseeds Research Area, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar India during 2018-19 were evaluated for twelve characters including days to 50 % flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, main shoot length (cm), number of siliquae on main shoot, siliquae length (cm), number of seeds per siliquae, 1000-seed weight (g), oil content (%) and seed yield per plant (g). Analysis of variance revealed that sufficient genetic variability present among parents and crosses for all of the traits. The results indicated presence of significantly high heterosis in desirable direction for all the characters except plant height (negative relative heterosis) and number of secondary branches/ number of seeds for per siliquae (economic heterosis). Two hybrids namely MA-9301 x MR-44 (12.85%) and MA-8701 x MR-38 (12.41%) showed significant positive economic heterosis over standard check DMH-1. These hybrids were identified as superior hybrids for their large-scale testing.

Keywords : *Brassica juncea, Gene action, GCA, heterosis, Mori CMS, SCA*

Introduction

Heterosis breeding is the foremost breeding method for improvement in cross pollinated crops but in self-pollinated crops like wheat, barley, rice, mustard etc. also successful at an optimal level. Self-pollinated crops expressed the lesser amount of heterosis as compared to cross pollinated species but this breeding method have capabilities to overcome the yield plateau barrier in self-pollinated crops (Allard, 1960). The utilization of F_1-hybrid for commercial exploitation is technically feasible in self-pollinated crops (Briggle, 1963). *Brassica juncea* L. is an important self-pollinated oilseed crop which occupies the premier position in Indian agriculture. It covers an area of 6.93 million ha with a production of 8.78 million tonnes and the average productivity of 1266 kg/ha in India in 2018-19 (Anonymous, 2019a). At present, India's maximum average productivity is much below than that of other Brassica growing countries. To feed the ever-increasing population, we are still importing more than 60% (14.01 million tonnes) of vegetable oils amounting to Rs 73,048 crores (Anonymous, 2017a). Furthermore, per capita consumption of edible oil is likely to reach 21.7 kg per annum by 2022 from the present level of 18 kg per annum (Anonymous, 2017b). To meet out the targeted oil requirements, there is an urgent need to further increase the yield potential of this crop. The development of genotypes with high seed yield and oil content has an important role to fill the gap between oil production and human population. Knowledge of heterosis provides fundamental information regarding the breeding techniques to be employed for crop improvement through hybrids development. Heterosis studies also help in rejecting a large number of crosses in F_1 generation itself and selecting only those having high yield potential. The identification of parental combinations that provide high heterosis for yield is the most important factor in hybrid development (Zhao *et al*., 2015). Heterosis breeding provides an opportunity for utilization of available variability and generates new variability that is important for development of climate resilient hybrid varieties. Hybrids have better adaptability to the changing environment and other biotic and abiotic stresses due to their internal balances and variability as compared to varieties or pure lines. Effective utilization of heterosis to develop high-yielding hybrids, therefore, has been the major objective of *Brassica* oilseed breeding in recent years. The main objective of the present study, therefore, was to isolate superior cross combination(s) by estimating relative heterosis, heterobeltiosis and economic heterosis in F_1 crosses of Indian mustard [*B. juncea* (L.) Czern & Coss.].

Materials and methods

The present investigation is based on *Mori* CMS system (male sterility and fertility restoration) as a pollination control mechanism. For making different cross combinations, 10 Mori CMS lines *viz*; MA-1-30, MA-023, MA-270, MA-8701, MA-8812, MA-9705, MA-9301, MA-9518, MA-9811 and MA-9702 were crossed with five testers *viz*; MR-9, MR-31, MR-38, MR-43 and MR-44 in Line x Tester fashion during rabi 2017-18. Fifty hybrids along with 10 Mori CMS lines, 5 testers and one hybrid check DMH-1 were planted in paired rows of four meter length with three replication and evaluated for twelve characters including days to 50 % flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, main shoot length (cm), number of siliquae on main shoot, siliquae length (cm), number of seeds per siliquae, 1000-seed weight (g), oil content (%) and seed yield per plant (g) during 2018-19. Five randomly selected competitive plants for each paired row were used for recording observations. Days to 50% flowering and days to maturity were recorded on plot basis. All the research work done at Oilseeds Research Area, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar. The mean of three replications for parents and F_1 crosses for twelve traits were subjected to statistical analysis of variance according to Sheoran *et al*. (1998) (Online OPSTAT software package). The experimental data recorded for various traits used for the estimation of relative heterosis, heterobeltiosis and economic heterosis following the method suggested by Shull (1908), Fonseca and Patterson (1968) and Meredith and Bridge (1972), respectively.

Results and discussion

Analysis of variance (Table 1) revealed highly significant (at P=0.01) differences among parents and F_1 crosses for all 12 traits indicating existence of considerable genetic variability in the research material. Similar results were also found by Meena *et al*. (2016). All three type of heterosis (relative, heterobeltiosis and economic heterosis) were observed significant in desirable direction for all the characters except plant height (relative negative heterosis) and number of secondary branches/ number of seeds for per siliquae (economic heterosis),where the estimate of heterosis was numerically high but non-significant (Table 2). In this paper terms "positive" and "negative" heterosis are used, meaning that the trait value is increased or decreased as compared to the mean of the parents or to the better parent or best check, DMH-1. Relative heterosishas less or no significance for plant breeders, so we discussed here only heterobeltiosis and economic heterosis.

One of the most important breeding objectives is the development of high yielding genotypes but despite that reduced plant height (negative heterosis for plant height) and earliness (negative heterosis for number of days to 50% flowering and days to maturity) also major breeding objectives for *Brassica* breeding. On the basis of estimates of better parent and economic heterosis, top 3 best

Table 1: Analysis of variance for twelve traits in Indian mustard

S.O.V Characters	D.F	Replication 2	Treatments 64	Error 128
Days to 50% maturity		13.19**	26.06**	2.23
Days to maturity		1.17	17.00**	3.81
Plant height (cm)		48.82	387.95**	63.96
Number of primary branches		0.59**	0.86**	0.21
Number of secondary branches		2.61**	8.64**	1.07
Main shoot length		118.5**	162.78**	23.09
Number of siliquae on main shoot		34.33*	120.44**	23.68
Siliquae length		0.01	0.41**	0.02
Number of seeds per siliquae		0.07	4.72**	0.28
1000 seed weight (g)		0.01	0.70**	0.01
Seed yield per plant (g)		23.24**	79.66**	9.03
Oil content (%)		0.02**	1.94**	0.01

**,* means significant at P = 0.01 and P = 0.05, respectively

Table 2: Top 3 best performing hybrids based on relative heterosis, heterobeltiosis and economic heterosis

S.No	Character	Top 3 Best performing Hybrids	Average parent	Heterosis over Better parent	DMH-1
1.	Days to 50% flowering	MA-023 x MR-43	-15.04**	-20.42**	-17.51**
		MA-9702 x MR-43	10.00**	-19.23**	-8.02**
		MA-270 x MR-44	-5.93*	-7.03*	-13.13**
2.	Days to maturity	MA-023 x MR-43	-3.54**	-5.76**	-2.85**
		MA-8812 x MR-44	-4.00**	-5.34**	-3.08**
		MA-270 x MR-44	-3.20**	-3.77**	-3.08**
3.	Plant height	MA-270 x MR-44	10.94**	3.15	-14.57**
		MA-1-30 x MR-44	7.44*	-3.97	-13.22**
		MA-9811 x MR-44	6.57*	-8.10 *	-9.73**
4	Number of primary branches	MA-9301 x MR-44	40.46**	40.46**	0.00
		MA-023 x MR-38	36.99**	30.72**	8.69
		MA-9811 x MR-9	7.37	6.25	16.84**
5.	Number of secondary branches	MA-023 x MR-38	49.42**	38.21**	0.78
		MA-9705 x MR-38	36.98**	29.64**	-5.47
		MA-8701 x MR-38	42.00**	26.79**	-7.55
6.	Main shoot length	MA-9518 x MR-44	28.82**	12.69*	22.19**
		MA-9518 x MR-9	16.33**	10.21	20.28**
		MA-9518 x MR-31	17.98**	9.68	19.70**
7.	Number of siliquae on main shoot	MA-8701 x MR-38	58.93**	57.09**	20.07**
		MA-023 x MR-38	39.71**	24.49**	18.84**
		MA-9518 x MR-44	42.36**	18.11**	17.74**
8.	Siliquae length	MA-9518 x MR-44	21.86**	18.02**	23.58**
		MA-9705 x MR-44	21.46**	15.65**	25.47**
		MA-9705 x MR-43	17.30**	13.93**	31.13**
9.	Number of seeds per siliquae	MA-1-30 x MR-44	37.48**	19.52**	-8.29**
		MA-8701 x MR-44	20.99**	17.72**	-9.67**
		MA-9705 x MR-44	22.51**	15.62**	-11.29**
10.	1000 seed weight	MA-9702 x MR-9	11.33**	0.58	40.98**
		MA-9702 x MR-44	0.00	-1.75	37.70**
		MA-9301 x MR-31	13.89**	7.19**	34.42**
11.	Seed yield per plant (g)	MA-9301 x MR-44	74.70**	22.31**	12.85*
		MA-8701 x MR-38	81.37**	55.89**	12.41*
		MA-023 x MR-38	48.76**	47.98**	7.84
12.	Oil content (%)	MA-1-30 x MR-9	7.17**	7.03**	3.26**
		MA-270 x MR-38	6.66**	6.39**	4.60**
		MA-270 x MR-43	6.24**	5.79**	4.02**

**,* means significant at P=0.01 and P= 0.05, respectively hybrids for 12 traits are presented in Table 2. Heterosis for days to 50% flowering was estimated over earlier flowering parent of the hybrids, hence negative heterosis is useful for days to flowering because early flowering genotypes transforms the vegetative phase energy into reproductive phase and this might gives better seed yield. The expression of negative heterosis for days to 50% flowering found significant in many crosses over the better parent and best check (DMH-1). The Cross combination MA-023 x MR-43 found best for both better parent negative heterosis (-20.42%) and economic heterosis (-17.51%). The top 3 cross combinations (Table 2) and other most of significant heterotic crosses for days to 50% flowering have two common testers i.e. MR-43 and MR-44 means these two testers are useful for development of future early maturity hybrids.

Negative heterosis, is useful regarding days to maturity because early maturing genotypes suffer lower losses due to shattering, tolerate or escape heat stress and insect attack and provide sufficient time for seeding the next crop. The desirable crosses over better parent and DMH-1 for early maturity were MA-023 x MR-43 (-5.76% &-2.85%), MA-8812 x MR-44 (-5.34% & -3.08%) and MA-270 x MR-44(-3.77 % & -3.08%), respectively. Negative heterosis is useful for the character plant height because dwarf plants with more numbers of branches are desirable due to their ability to withstand winds (lodging resistant) and dwarf varieties demanded by farmers in present farming system. The desirable crosses for plant height were MA-270 x MR-44 (-14.57%), MA-1-30 x MR-44 (-13.22%), MA-9702 x MR-44 (-11.00%) and MA-270 x MR-43 (-9.77%) showed negative heterosis over standard check DMH-1. The present findings are similar to the earlier report of Thanmichon *et al*. (2018) who reported significant negative heterosis for days to 50% flowering, days to maturity and plant height in two crosses *viz;* DRMR-15 x SEJ-2 and DRMR 150-35 x Pusa Bold.

Positive heterosis for number of primary branches is desirable, because plants with robust stature containing more number of primary branches provide opportunity for higher yields. Only one cross MA-9811 x MR-9 depicted significant positive economic heterosis for this trait with the magnitude of heterosis 16.84 per cent, but crosses MA-023 x MR-38 (8.69%) and MA-8812 x MR-9 (3.26%) were also showed positive economic heterosis.None of the cross depicted significant positive economic heterosis for number of secondary branches per plant but crosses *viz*; MA-023 x MR-38 (38.21%), MA-9705 x MR-38 (29.64%) and MA-8701 x MR-38 (26.79%) showed significant better parent heterosis. Heterotic responses for main shoot length showed that crosses, MA-9518 x MR-44 (22.99%), MA-9518 x MR-9 (20.28%) and MA-9518 x MR-38 (19.70%) were found superior than standard check DMH-1. The parent MA-9518 was found common in most of heterotic cross combination. This parent might be useful in future breeding program for main shoot length improvement.

The significant positive economic heterotic response for number of siliquae on main shoot was observed in six crosses but best three crosses, MA-8701 x MR-38 (20.07%), MA-023 x MR-38 (18.84%) and MA-9518 x MR-44 (17.74%) were found heterotic over DMH-1. These three crosses also showed significant heterobeltiosis for same trait.Expression of economic heterosis for siliquae length found significant in 43 cross combinations but four crosses, MA-9518 x MR-44 (18.02%), MA-9705 x MR-44 (15.65%), MA-9705 x MR-43 (13.93%) and MA-8701 x MR-44 (13.46%) were showed significant heterosis over better parent.

The heterosis results for number of seeds per siliquae showed that 11 crosses were found significant over better parent heterosis for this trait with extent of heterosis ranged from 8.70 (MA-9702 x MR-9) to 19.52 per cent (MA-1-30 x MR-44). None of the cross exhibited positive significant economic heterosis for number of seeds per silique. Expression of heterosis for 1000 seed weight showed that only one cross, MA-9301 x MR-31 exhibited positive significant heterobeltiosis for this trait with the extent of heterosis 7.19 per cent. All crosses depicted significant positive economic heterosis for 1000-seed weight with magnitude of heterosis ranged from 7.37 (MA-270 x MR-38) to 40.98 per cent (MA-9702 x MR-9) over the best standard check DMH-1.

Nineteen crosses showed significant positive heterobeltiosis for seed yield per plant with the extent of heterosis ranging from 21.22 (MA-8812 x MR-31) to 140.64 per cent (MA-9705 x MR-44). Maximum significant positive heterosis for seed yield per plant trait was exhibited by the cross MA-9301 x MR-44 (12.85 per cent) followed by cross MA-8701 x MR-38 (12.41 per cent) over the best standard check DMH-1. Other 11 crosses *viz*; MA-8812 x MR-9 (8.06%), MA-023 x MR-38 (7.84%), MA-9705 x MR-31 (5.01%), MA-8701 x MR-9 (4.35%), MA-8812 x MR-31 (3.92%), MA-1-30 x MR-9 (3.48%), MA-023 x MR-9 (3.37%), MA-8812 x MR-44 (3.15%), MA-9301 x MR-9 (1.30%), MA-9705 x MR-38 (1.19%) and MA-9301 x MR-31 (0.43%) also showed positive economic heterosis with higher per se performance. Crosses, MA-9705 x MR-44 (140.64%), MA-1-30 x MR-44 (106.21%), MA-9518 x MR-44 (72.15%) and MA-8701 x MR-44 (71.64%) were showed very high heterobeltiosis (more than 50%). Similarly, Rashmi *et. al.* (2018) reported 112.43% better parent heterosis in hybrid Maya x IC-414317.

The expression of heterosis for oil content was observed very low. Nine crosses exhibited significant positive heterobeltiosis for this trait with the magnitude of heterosis ranged from 0.68 (MA-9702 x MR-44) to 7.03 per cent (MA-1-30 x MR-9). Seven crosses showed significant positive economic heterosis for this trait with the extent of heterosis ranged from 1.00 (MA-8812 x MR-9) to 4.60 per cent (MA-270 x MR-38).A similar finding with low hetrosis for oil content was reported by Prajapati *et. al*. (2018).

On the basis of overall study of heterosis the best four crosses *viz*; MA-9301 x MR-44, MA-8701 x MR-38, MA-8812 x MR-9 and MA-023 x MR-38. Cross, MA-9301 x MR-44 was found significant for days to 50% flowering, days to maturity, plant height, number of primary branches, main shoot length, siliquae length, 1000-seed weight, seed yield per plant; Cross, MA8701 x MR-38 for main shoot length, number of siliquae on main shoot, siliquae length, 1000 seed weight, and seed yield per plant; Cross, MA-8812 x MR-9 for days to 50% flowering, number of primary branches per plant, number of secondary branches per plant, siliquae length, 1000 seed weight, seed yield per plant and oil content and cross, MA-023 x MR- 38 for days to 50% flowering, number of primary branches per plant, number of secondary branches per plant, main shoot length, number of siliquae on main shoot,siliquae length, 1000 seed weight, and seed yield per plant.The results of this study are similar to earlier findings of Thanmichon *et al*. (2018) who reported positive better parent heterosis (DRMR 150-35 x Pusa bold) for number of primary branches per plant, number of secondary branches per plant, siliquae length and number of seeds per siliquae. Hence significant heterosis for seed yield per plant was the result of combined effect of other yield contributing traits therefore; the selection of high yielding genotypes should be based on multiple characters rather than a single character. From above discussion it can be concluded that above four crosses needed large scale testing to develop a superior hybrid with high and stable seed yield in *Brassica juncea* L.

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