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Heterosis for yield and its component traits in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]

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Abstract

Indian mustard is a most widely cultivated oilseed crop of India. The productivity of this crop should be boost up in order to meet out the future edible oils demand of the country. Heterosis breeding could be a potential alternative for increasing productivity of Indian mustard. Therefore, 40 crosses had developed in Line x Tester fashion in order to study the extent of heterosis for yield and its component traits in Indian mustard. In terms of heterotic effects for both seed yield and oil content, four best hybrids were RH 1599-44 × DRMR 2035, RH 1599-44 × EC 597328, PM 26 × DRMR 2035 and RH 1658 × EC 597328. Besides, heterosis for seed and oil yield, later two crosses also expressed significant heterotic effects for most of the yield attributing and agronomically desirable traits. These cross-combinations can have potential to serve as commercial F_1 hybrids after transferring them in to suitable cytoplasmic genetic male sterility system.

Keywords: Indian mustard, productivity, Line x Tester mating design, Heterosis

Introduction

Brassica oilseeds are the important group of oilseed crops India. Among them, Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is an important oilseed crop and alone contributes more than 90% of the total brassica oilseeds production of the country [1]. However, the production and productivity of Indian mustard is still low as compared to current demand of edible oils of the country [2]. Therefore, productivity of Indian mustard should be boost up in order to meet out the present demand of edible oils in India. In the past, crop improvement in Indian mustard mainly focused through line breeding programs. However, the average yield of Indian mustard still is very low in India as compared to other countries, therefore, much attention must be given to increase it by developing new cultivars or hybrids through sound breeding programs [3, 4]. Hybrid breeding could be a potential alternative for substantially increasing the productivity of Indian mustard [5]. Heterosis breeding is an important genetic tool that can facilitate yield enhancement from 30 to 400% and helps enrich many other desirable quantitative and qualitative traits in crops plants [6]. Successful exploitation of heterosis would depend upon the identification of F_1 crosses that are more productive than either of their parents and the best available cultivar used as a check. Therefore, we evaluated different cross combinations with the objective to study the extent of heterosis for yield and its component traits in Indian mustard.

Materials and Methods

Experimental plant materials

The experimental materials under present experiment were comprised of 14 genotypes. Out of which, 10 genotypes *viz*., RH 1566, RH 1569, RH 1633, RH 1657, 1658, RH 1664, RH 1599-41, RH 1599-44, RH 1899-53 & PM 26 were used as lines while four genotypes *viz.*, RH 1222-28, DRMR 2035, EC 597328 & EC 597317 were used as testers. Forty crosses were made in a Line × Tester mating fashion by taking above-mentioned 10 lines and 4 testers during *Rabi* season of 2018-19. Thus, the experiment comprising fourteen parents and forty crosses along with two standard checks (RH 0749 and RH 725) that were grown in Randomized Complete Block Design (RCBD) with three replications at Research Farm of Department of Genetics and Plant Breeding, CCS HAU, Hisar during *Rabi* season of 2019-20. The plots size was paired row of 4 m length each with three replications having row-to-row spacing of 30 cm. All the recommended package of practices were adopted to raise a good crop.

Observations recorded

To study the heterosis for yield and its attributing traits, five randomly selected competitive plants (from both rows) from each genotype (Parents + Crosses + Standard checks) in each replication were tagged. The following observations were recorded from the tagged plants except for days to 50% flowering and days to maturity, where, observations were recorded on whole paired row basis:

1. Days to 50% flowering: It was recorded by counting days from the date of sowing to the date when 50 *per cent* plants come to flowering in paired rows.
2. Days to maturity: It was recorded by counting days from the date of sowing to the date when 75 *per cent* siliquae on main branch reached the physiological maturity.
3. Plant height (cm): It was measured from the ground level to the tip of the main raceme at the time of maturity.
4. Number of primary branches per plant: It was recorded at the time of maturity by counting the number of branches emerging directly from the main stem which bearing siliquae.
5. Number of secondary branches per plant: It was recorded at the time of maturity by counting the number of siliquae bearing branches emerging from the primary branches.
6. Main shoot length (cm): The length of the main raceme was measured at the time of maturity in centi-meters from the point it emerges out from main stem up to the end point of it.
7. Number of siliquae on shoot: Total numbers of siliquae on main shoot were counted. Five siliquae taken for measuring siliqua length were also added in total number.
8. Siliqua length (cm): Five siliquae were taken at random from the main raceme of each plant. The length was measured in centi-meters and then average siliqua length was calculated.
9. Number of seeds per siliqua: The number of seeds in five siliquae used for measuring average siliqua length were counted and averaged.
10. 1000 seed weight (g): One thousand seeds counted from each plant in each replication were weighed in grams on digital electronic balances.
11. Seed yield per plant (g): All the siliquae of the tagged plants at maturity were threshed and seeds were weighed in grams on digital electronic balance. The seed yield per plant (g) was then averaged.
12. Oil content (%): Seed samples were taken from five tagged plants from each replication and oil content was determined using soxhlet apparatus.

Estimation of heterosis

Heterosis expressed as per cent increase or decrease in F_1 over mid (relative heterosis), over better parent (heterobeltiosis) and over standard checks (economic heterosis) was calculated by formulae suggested:

$$Relative\ heterosis\ (\%) = \frac{\overline{F}_1 - \overline{MP}}{\overline{MP}} \times 100$$

$$Heterobeltiosis\ (\%) = \frac{\overline{F}_1 - \overline{BP}}{\overline{BP}} \times 100$$

$$Standard\ heterosis\ (\%) = \frac{\overline{F}_1 - \overline{SC}}{\overline{SC}} \times 100$$

Where

$\overline{F}_1$ = Mean value of F_1

$\overline{MP}$ = Mid parent value which was calculated using the formula:

$$\overline{MP} = \frac{\overline{P}_1 + \overline{P}_2}{2}$$

$\overline{BP}$ = Mean value of better parent

$\overline{SC}$ = Mean value of standard check

Testing of significance for heterosis

The student 't' test was applied to determine the significance of heterosis by using the following formulae:

$$'t'\ (Relative\ heterosis) = \frac{\overline{F}_1 - \overline{MP}}{SE\ (d)}$$

$$'t'\ (Heterobeltiosis) = \frac{\overline{F}_1 - \overline{BP}}{SE\ (d)}$$

$$'t'\ (Standard\ heterosis) = \frac{\overline{F}_1 - \overline{SC}}{SE\ (d)}$$

Where

SE (d) is the standard error of difference which is calculated as $SE\ (d) = \sqrt{\frac{2Me}{r}}$

Me = Mean sum of square due to error

r = No. of replications

The calculated 't' values were compared with the table value of 't' at error degree of freedom for testing the significance of heterosis.

Results

Analysis of variance (Table 1) showed significant difference among genotypes (parents + crosses + checks) for all the studied traits.

Heterosis

Heterosis measured as deviation of the F_1 hybrid performance from the mid parent (relative heterosis), that of superior parent (heterobeltiosis) and best checks (standard heterosis) was calculated for various characters and expressed in percentage (Table 2-7). Brief descriptions of the heterotic response of the hybrids for various characters are given below:

Days to 50% flowering

As early flowering and maturity is desirable agronomic trait so parent which was early for these traits considered as better parent while calculating better parent heterosis. The results for days to 50% flowering revealed that range of heterosis was observed to be from -21.74 to 1.52 *per cent* over mid parent, -32.08 to -3.77% over better parent and -23.91 to 10.87% over standard checks *viz.*, RH 725 and RH 0749. Out of 40 F_1 hybrids, 35 exhibited significant heterosis in negative direction over mid parent, 38 over better parent and 24 over standard checks. The hybrid RH 1599-41 × EC 597317 exhibited maximum mid parent heterosis in negative direction (-21.74%) followed by RH 1657 × EC 597317 (-20.83%), RH 1658 × DRMR 2035 (-20.45%) and RH 1599-41 × RH 1222-28 (-20.00%). The hybrids RH 1599-41 × EC 597317 and PM 26 × EC 597317 exhibited highest negative better parent heterosis (-32.08%) followed by RH 1658 × DRMR 2035 (-30.00%). The maximum standard heterosis was exhibited by the cross RH 1658 × DRMR 2035 (-23.91%). Thus, RH 1658 × DRMR 2035 was the best heterotic hybrid for this trait.

Days to maturity

Early maturity is the desirable agronomic trait. Therefore, heterosis for earliness is important for developing early maturing hybrids. The range of heterosis was observed from -6.01 to 4.68 over mid parent, -7.43 to 3.36 over better parent and -7.59 to 2.17 over RH 725, -9.36 to 0.21 over RH 0749. Among 40 F_1 hybrids, 3 exhibited significant negative heterosis over mid parent, 8 over better parent, while 5 over standard check RH 725 and 11 over standard check RH 0749. The hybrid RH 1566 × EC 597328 manifested highest significant mid parent heterosis in negative direction (-6.01%) followed by RH 1658 × RH 1222-28 (-5.40%) and RH 1657 × EC 597328 (-5.39%). While, the hybrid RH 1599-41 × RH 1222-28 exhibited maximum negative heterosis over better parent (-7.43%) followed by RH 1658 × RH 1222-28 (-7.01%) and RH 1657 × EC 597328 (-6.93%). Over standard checks, the hybrid RH 1599-41 × RH 1222-28 showed highest heterosis in negative direction (-7.43% over RH 725 and -9.36% over RH 0749) followed by RH 1657 × EC 597328 and PM 26 × EC 597328 (-6.73% over RH 725 and -8.51% over RH 0749).

Plant height (cm)

Short plant stature is considered agronomically desirable trait. Consequently, heterosis in negative direction for plant height is vital and we had taken low height parent as better parent while calculating better parent heterosis. For this trait, the range of heterosis was observed from -11.74 to 9.20% over mid parent, -19.32 to 2.47% over better parent, -14.60 to -0.60% over RH 725 and –13.01 to 1.63% over RH 0749. Out of 40 F_1 hybrids, 5 exhibited significant negative heterosis over mid parent, 14 over better parent, 13 over standard check-I (RH 725) while 10 over standard check-II (RH 0749). The hybrid RH 1599-44 × DRMR 2035 manifested highest mid parent heterosis (-11.74%) in negative direction followed by RH 1657 × DRMR 2035 (-10.55%) while the cross RH 1658 × DRMR 2035 exhibited maximum better parent heterosis (-19.32%) and standard heterosis (-14.60% over RH 725 and -13.01% over RH 0749) followed by PM 26 × DRMR 2035 (-18.89% over better parent; -14.14% over RH 725 and -12.55% over RH 0749). Thus, PM 26 × DRMR 2035 was the best cross combination for short plant stature.

Number of primary branches per plant

The range of heterosis for this trait was observed to be from -29.50 to 31.60% over mid parent -32.57 to 22.68% over better parent, -27.89 to 23.01% over standard check-I (RH 725) and -13.83 to 47.00% over standard check-II (RH 0749). Among 40 F_1 hybrids, nine exhibited significant heterosis in positive direction over mid parent, six over better parent, five over standard check-I namely RH 725 and 22 over standard check-II (RH 0749). Among 40 F_1hybrids, nine exhibited significant heterosis in positive direction over mid parent, six over better parent, five over standard check-I namely RH 725 and 22 over standard check-II (RH 0749). The hybrid RH 1664 × RH 1222-28 manifested highest mid parent heterosis (31.60%) followed by RH 1658 × EC 597328 (30.74%) and RH 1664 × EC 597328 (29.80%). The hybrid RH 1658 × EC 597328 showed highest better parent heterosis (22.68%) followed by RH 1664 × EC 597328 (20.18%) and RH 1664 × RH 1222-28 (19.10%). While, the hybrid RH 1664 × RH 1222-28 exhibited maximum standard heterosis (16.32% over RH 725 and 39.00% over RH 0749) followed by RH 1657 × RH 1222-28 and RH 1658 × EC 597328 (13.95% over RH 725 and 36.17% over RH 0749).

Number of secondary branches per plant

Ample variation of heterosis was observed for this trait, which ranged from -23.27 to 40.10% over mid parent, -34.22 to 33.33% over better parent, -10.65 to 50.00% over RH 725 and -6.98 to 56.15 over RH 0749. Out of 40 F_1 hybrids, 12 exhibited significant positive heterosis over mid parent, six over better parent, 21 over RH 725 (standard check-I) and 24 over RH 0749 (standard check-II). The hybrid RH 1664 × RH 1222-28 manifested highest mid parent heterosis (40.10%) followed by RH 1569 × RH 1222-28 (36.41%) and PM 26 × DRMR 2035 (33.62%). The hybrid RH 1569 × RH 1222-28 showed maximum better parent heterosis (33.33%) followed by RH 1664 × RH 1222-28 (30.19%) and RH 1599-44 × RH 1222-28 (25.49%). While, the hybrid PM 26 × DRMR 2036 manifested maximum standard heterosis in positive direction (50.00% over RH 725 and 56.15% over RH 0749) followed by RH 1569 × RH 1222-28 (45.12% over RH 725 and 51.07% over RH 0749). These hybrids were promising for this trait.

Main shoot length (cm)

The outcomes for main shoot length revealed that heterosis ranged between -8.75 to 25.76% over mid parent, -14.42 to 23.53% over better parent, -8.97 to 22.76 over RH 725 and -8.21 to 23.78 over RH 0749. Out of 40 crosses, 24 exhibited significant heterosis in positive direction over mid parent, 21 over better parent, 12 over standard check-I (RH 725) and 14 over standard check-II (RH 0749) for this trait. The hybrid RH 1569 × EC 597328 showed highest mid parent heterosis (25.76%) followed by RH 1658 × RH 1222-28 (24.05%) and RH 1899-53 × EC 597328 (22.00%). For better parent heterosis (BPH), the cross-combination RH 1658 × RH 1222-28 was found most promising (BPH = 23.53%) followed by RH 1899-53 × EC 597328 (BPH = 21.45%). While, for standard heterosis (SH), the hybrid RH 1658 × RH 1222-28 was found most heterotic over both the standard checks (22.76% heterosis over RH 725 and 23.78% over RH 0749) followed by RH 1633 × EC 597328 which showed 20.47 and 21.47 *per cent* heterosis over RH725and RH0749, respectively.

Number of siliquae on main shoot

Among different crosses, heterosis over mid parent varied from -25.03% in RH 1657 × EC 597317 to 29.07% in RH 1664 × EC 597328. Nine crosses had significant positive heterosis over mid parent while, only three crosses exhibited significant positive heterosis over better parent. The maximum heterobeltiosis was exhibited by cross combination RH 1569 × EC 597328 (22.89%) followed by RH 1664 × EC

597328 (18.28%) and RH 1899-53 × EC 597328 (14.87%). Only one hybrid *viz.*, RH 1569 × EC 597328 manifested significant positive heterosis (18.46%) over RH 725 while, 17 hybrids showed significant positive heterosis over RH 0749. Among them, RH 1569 × EC 597328 had maximum heterosis (35.82%) followed by RH 1664 × EC 597328 (24.43%). Thus, RH 1569 × EC 597328 was the best heterotic cross for this trait.

Siliqua length (cm)

Siliqua length is an important component for seed yield because longer siliqua is directly proportional to number of seeds per siliqua. Therefore, positive heterosis for this trait is essential for improving seed yield. Results of present study revealed that mid parent heterosis varied from -7.87 to 30.30 while heterobeltiosis varied from -13.33 to 28.72. Among various crosses, 28 and 14 hybrids showed significant positive heterosis over mid parent and better parent, respectively. Highest significant relative heterosis was exhibited by the cross RH 1658 × DRMR 2035 (30.30%) followed by PM 26 × DRMR 2035 (29.18%) and RH 1657 × DRMR 2035 (28.78%). The hybrid RH 1657 × DRMR 2035 manifested highest heterobeltiosis (28.72%) followed by PM 26 × DRMR 2035 (26.85%) and RH 1658 × DRMR 2035 (21.67%). A single cross namely RH 1569 × EC 597328 (12.21%) showed significant positive heterosis over RH 725 while nine cross combination showed significant positive heterosis over RH 0749 and highest (23.95%) was observed in RH 1569 × EC 597328 followed by RH 1633 × EC 597328 (13.95%) and RH 1658 × DRMR 2035 (13.26%).

Number of seeds per siliqua

It is evident from Table 6 that heterosis for number of seeds per siliqua varied from -8.87 to 29.22% over mid parent, -16.29 to 26.25% over better parent, -8.01 to 22.40% over standard check-I and -14.08 to 14.33% over standard check-II. Thirty hybrids showed significant positive mid parent heterosis with maximum extent (29.22%) in RH 1599-44 × DRMR 2035 followed by RH 1899-53 × EC 597328 (26.25%) and RH 1599-41 × EC 597317 (24.06). Significant heterosis in positive direction over better parent was exhibited by 18 crosses, out of which, the cross RH 1899-53 × EC 597328 showed highest heterobeltiosis (26.25%) followed by RH 1599-44 × RH 1222-28 (22.49%) and RH 1566 × DRMR 2035 (19.59%). Over standard check-I, a total of 17 crosses showed significant positive heterosis and highest heterosis (22.40%) was manifested by cross RH 1599-41 × EC 597317 followed by PM 26 × RH 1222-28 (17.11%) and RH 1599-44 × DRMR 2035 (16.97%). While, only two crosses namely RH 1599-41 × EC 597317 and RH 1599-44 × DRMR 2035 showed significant positive heterosis over standard check-II with an estimate of 14.33 and 9.26 *per cent*, respectively.

1000-seed weight (g)

The trait 1000-seed weight is an important component of seed yield. Positive heterosis for this trait is desirable which contributes to higher *per se* yield. In case of mid parent heterosis, 17 hybrids showed significant positive heterosis which ranged from -18.48 to 21.31%. While, for better parent heterosis, 10 showed significant positive heterosis with ranged from -22.70 to 12.28. The hybrid RH 1633 × EC 597317 showed highest mid parent heterosis (21.31%) followed by PM 26 × DRMR 2035 (18.32) and RH 1899-53 × DRMR 2035 (16.74%). The maximum better parent heterosis was manifested by hybrid RH 1633 × RH 1222-28 (12.28%) followed by RH 1899-53 × EC 597328 (10.63%) and PM 26 × EC 597328 (10.18%). Standard heterosis over RH 725 ranged between -33.55 to 10.54 and over standard check-II (RH 0749), it varied from -38.73 to 1.91. Out of 40 crosses, only two hybrids *viz.*, RH 1633 × RH 1222-28 (10.54%) and RH 1633 × EC 597317 (7.35%) showed significant positive heterosis over standard check-I (RH 725) while none of the hybrid showed significant positive heterosis over standard check-II (RH 0749).

Seed yield per plant (g)

The results for seed yield per plant revealed that range of heterosis was observed from -11.83 to 75.04 over mid parent, -17.67 to 61.52 over better parent and -27.83 to 12.75 over RH 725, -24.15 to 18.49 over RH 0749. Out of 40 F_1 hybrids, 21 exhibited significant heterosis in positive direction over mid parent, 8 over better parent, while none of these hybrids showed significant positive heterosis over standard checks for this trait. The hybrid PM 26 × DRMR 2035 manifested highest significant mid parent (75.04%) and better parent (61.52%) heterosis followed by RH 1599-44 × DRMR 2035 (MPH = 66.04%; BPH = 44.26%), RH 1664 × RH 1222-28 (MPH = 52.29%; BPH = 42.59%) and RH 1599-44 × EC 597328 (MPH = 51.45%; BPH 42.32%). The hybrid RH 1658 × EC 597328 showed maximum heterosis over standard checks *viz.* RH 725 (12.75%) and RH 0749 (18.49%) followed by RH 1664 × RH 1222-28 which exhibited 10.59% heterosis over RH 725 and 16.23% over RH 0749.

Oil content (%)

The data pertaining to heterosis for oil content is presented in Table 7. Mid parent heterosis was ranged between -3.77 to 3.80 *per cent* while better parent heterosis varied from -3.81 to 3.53 *per cent*. Fourteen and six hybrids showed significant positive heterosis over mid and better parent, respectively. Highest significant positive heterosis over mid (MPH) and better parent (BPH) was observed in PM 26 × DRMR 2035 (MPH = 3.80% and BPH = 3.53%) followed by RH 1566 × DRMR 2035 (MPH = 3.49% and BPH = 3.44%) and RH 1658 × EC 597328 (MPH = 3.28% and BPH = 3.01%). Single hybrid namely RH 1599-44 × DRMR 2035 exhibited significant positive heterosis over RH 725 (standard check-I) while 12 crosses showed significant positive heterosis over RH 0749 (standard check-II). Among these 12 crosses, the hybrid RH 1599-44 × DRMR 2035 showed maximum heterosis (3.69%) over RH 0749 followed by RH 1566 × DRMR 2035 and PM 26 × DRMR 2035, both of them were showed 3.27 *per cent* heterosis over RH 0749 for this trait.

Discussion

According to Shull (1914), heterosis phenomenon is the manifestation of phenotypic superiority by F_1 hybrid over the parental values. The magnitude of the heterotic effect will define the success of a hybrid breeding program. Heterosis for seed yield and its components is well reported earlier in Indian mustard [7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23]. The ANOVA revealed high degree of genetic variability existing among parents and hybrids for all characters studied. The contrast of parents versus crosses was substantial and statistically significant for most of the characters indicating the potential of heterotic effects among F_1 hybrids. Heterosis in a positive direction is highly desirable for yield attributing traits *viz*. number of primary and secondary branches per plant, number of siliquae on main shoot, siliqua length, number of seeds per siliqua and 1000-seed weight. The extent of heterosis varied considerably for different characters with the maximum favorable heterosis for the number of secondary and primary branches per plant followed by days to flowering, number of siliquae on main shoot and number of seeds per siliqua. According to Labana *et al*. [24], seed yield increased in majority of heterotic combinations resulted from increased primary and secondary branches number. Therefore, seed yield can be improved by exploiting hybrid vigor of these traits. The present results are in agreements with previous findings [11, 15, 25, 26, 27, 28]. In terms of heterotic effects for both seed yield and oil content, four best hybrids were RH 1599-44 × DRMR 2035, RH 1599-44 × EC 597328, PM 26 × DRMR 2035 and RH 1658 × EC 597328. Besides, heterosis for seed and oil yield, later two crosses also expressed significant heterotic effects for most of the yield attributing and agronomically desirable traits.

Table 1: Analysis of variance (ANOVA) for Randomized Complete Block Design (RCBD) for seed yield and its component traits in Indian mustard

SV	df	Mean squares											
		DF	**DM**	**PH**	**NPB**	**NSB**	**MSL**	**NSMS**	**SL**	**NSS**	**TSW**	**SYP**	**OC**
Blocks	2	97.79	25.45	2.96	1.59	26.02	38.71	92.91	0.01	0.02	0.00	0.80	0.03
Genotypes	55	67.67**	57.57**	521.95**	2.10**	18.24**	136.67**	82.76**	0.48**	4.06**	1.50**	40.52**	1.04**
Error	110	3.57	28.54	116.59	0.30	2.49	17.35	13.40	0.06	0.76	0.03	13.61	0.02

*Significant at $P \leq 0.05$ and **Significant at $P \leq 0.01$. DF-Days to flowering, DM-Days to maturity, PH-Plant height (cm), NPB-Number of primary branches per plant, NSB-Number of secondary branches per plant, MSL-Main shoot length (cm), NSMS-Number of siliquae on main shoot, SL-Siliqua length (cm), NSS-Number of seeds per siliqua, TSW-1000 seed weight (g), SYP-Seed yield per plant (g), OC-Oil content (%)

Table 2: Percent relative heterosis (RH), heterobeltiosis (HB) and standard heterosis for days to flowering (50%) and days to maturity in Indian mustard

Sr. No.	Hybrids	Days to flowering (50%)				Days to maturity			
		RH	HB	Standard heterosis over		RH	HB	Standard heterosis over	
				RH 725	RH 0749			RH 725	RH 0749
1.	RH 1566 × RH 1222-28	-10.68**	-11.54**	0.00	0.00	-1.17	-1.27	0.87	-1.07
2.	RH 1566 × DRMR 2035	-11.76**	-13.46**	-2.17	-2.17	1.19	-0.85	1.08	-0.86
3.	RH 1566 × EC 597328	-6.00*	-9.62**	2.17	2.17	-6.01*	-6.81*	-4.99	-6.81*
4.	RH 1566 × EC 597317	-4.76*	-5.66*	8.70*	8.70*	3.18	0.21	2.17	0.21
5.	RH 1569 × RH 1222-28	-9.09**	-11.76**	-2.17	-2.17	-1.84	-3.82	-1.74	-3.62
6.	RH 1569 × DRMR 2035	-12.24**	-14.00**	-6.52	-6.52	0.78	0.66	-1.30	-3.19
7.	RH 1569 × EC 597328	-6.25*	-6.25*	-2.17	-2.17	-2.63	-3.68	-3.47	-5.32
8.	RH 1569 × EC 597317	0.99	-3.77	10.87**	10.87**	1.68	0.66	-1.30	-3.19
9.	RH 1599-41 × RH 1222-28	-20.00**	-29.41**	-21.74**	-21.74**	-2.57	-7.43**	-5.43	-7.24*
10.	RH 1599-41 × DRMR 2035	-19.10**	-28.00**	-21.74**	-21.74**	-2.63	-5.54*	-7.59**	-9.36**
11.	RH 1599-41 × EC 597328	-8.05**	-16.67**	-13.04**	-13.04**	-2.26	-6.28*	-6.08*	-7.88**
12.	RH 1599-41 × EC 597317	-21.74**	-32.08**	-21.74**	-21.74**	3.11	0.90	-3.04	-4.90
13.	RH 1599-44 × RH 1222-28	-13.40**	-17.65**	-8.70*	-8.70*	0.21	-0.85	1.30	-0.64
14.	RH 1599-44 × DRMR 2035	-14.58**	-18.00**	-10.87**	-10.87**	0.00	-1.08	-1.09	-2.98
15.	RH 1599-44 × EC 597328	-8.51**	-10.42**	-6.52	-6.52	-1.63	-1.73	-1.52	-3.41
16.	RH 1599-44 × EC 597317	-19.19**	-24.53**	-13.04**	-13.04**	-3.76	-5.64*	-5.64*	-7.45**
17.	RH 1633 × RH 1222-28	6.52 *	-3.92	6.52	6.52	0.44	-2.12	0.00	-1.91
18.	RH 1633 × DRMR 2035	-1.10	-10.00**	-2.17	-2.17	3.79	3.33	1.08	-0.86
19.	RH 1633 × EC 597328	1.12	-6.25*	-2.17	-2.17	-0.77	-2.38	-2.17	-4.05
20.	RH 1633 × EC 597317	-2.13	-13.21**	0.00	0.00	3.82	3.36	0.21	-1.70
21.	RH 1657 × RH 1222-28	-14.89**	-21.57**	-13.04**	-13.04**	-2.40	-4.88	-2.82	-4.69
22.	RH 1657 × DRMR 2035	-13.98**	-20.00**	-13.04**	-13.04**	-0.45	-0.89	-3.04	-4.90
23.	RH 1657 × EC 597328	-12.09**	-16.67**	-13.04**	-13.04**	-5.39*	-6.93 *	-6.73*	-8.51**
24.	RH 1657 × EC 597317	-20.83**	-28.30**	-17.39**	-17.39**	-1.57	-2.01	-4.99	-6.81*
25.	RH 1658 × RH 1222-28	-19.10**	-29.41**	-21.74**	-21.74**	-5.40*	-7.01**	-4.99	-6.81*
26.	RH 1658 × DRMR 2035	-20.45**	-30.00**	-23.91**	-23.91**	-2.43	-2.86	-4.13	-5.96*
27.	RH 1658 × EC 597328	-13.95**	-22.92**	-19.57**	-19.57**	-1.64	-2.38	-2.17	-4.05
28.	RH 1658 × EC 597317	-16.48**	-28.30**	-17.39**	-17.39**	-2.45	-3.74	-4.99	-6.81*
29.	RH 1664 × RH 1222-28	-14.89**	-21.57**	-13.04**	-13.04**	0.77	-3.18	-1.09	-2.98
30.	RH 1664 × DRMR 2035	-16.13**	-22.00**	-15.22**	-15.22**	1.92	0.00	-2.17	-4.05
31.	RH 1664 × EC 597328	-16.48**	-20.83**	-17.39**	-17.39**	-0.67	-3.68	-3.47	-5.32
32.	RH 1664 × EC 597317	-12.50**	-20.75**	-8.70*	-8.70*	1.94	0.90	-3.04	-4.90
33.	RH 1899-53 × RH 1222-28	-7.22**	-11.76**	-2.17	-2.17	-4.06	-4.67	-2.60	-4.47
34.	RH 1899-53 × DRMR 2035	-10.42**	-14.00**	-6.52	-6.52	-1.09	-2.58	-1.74	-3.62
35.	RH 1899-53 × EC 597328	-17.02**	-18.75**	-15.22**	-15.22**	-0.32	-0.65	0.21	-1.70
36.	RH 1899-53 × EC 597317	-5.05*	-11.32**	2.17	2.17	2.42	0.00	0.87	-1.07
37.	PM 26 × RH 1222-28	-8.05**	-21.57**	-13.04**	-13.04**	2.95	-3.61	-1.52	-3.41
38.	PM 26 × DRMR 2035	-11.63**	-24.00**	-17.39**	-17.39**	3.94	-0.67	-2.82	-4.69

39.	PM 26 × EC 597328	-2.38	-14.58**	-10.87**	-10.87**	-1.49	-6.93 *	-6.73*	-8.51**
40.	PM 26 × EC 597317	-19.10**	-32.08**	-21.74**	-21.74**	4.68	0.90	-3.04	-4.90

*Significant at $P \leq 0.05$ and **Significant at $P \leq 0.01$

Table 3: Percent relative heterosis (RH), heterobeltiosis (HB) and standard heterosis for plant height (cm) and number of primary branches per plant in Indian mustard

Sr. No.	Hybrids	Plant height (cm)				Number of primary branches per plant			
		RH	HB	Standard heterosis over		RH	HB	Standard heterosis over	
				Check-I (RH 725)	Check-II (RH 0749)			Check-I (RH 725)	Check-II (RH 0749)
1.	RH 1566 × RH 1222-28	-2.58	-3.18	-0.61	1.24	9.52	9.52	6.97	27.83**
2.	RH 1566 × DRMR 2035	-7.73*	-9.12*	-3.80	-2.01	-1.15	-4.44	0.00	19.50**
3.	RH 1566 × EC 597328	-3.41	-6.07	-3.57	-1.78	7.79	5.14	2.65	22.67**
4.	RH 1566 × EC 597317	-4.82	-7.11	-4.64	-2.87	-29.50**	-32.57**	-27.89**	-13.83
5.	RH 1569 × RH 1222-28	-6.59	-7.82	-6.54	-4.80	13.68*	8.74	16.32**	39.00**
6.	RH 1569 × DRMR 2035	-2.45	-5.75	-0.23	1.63	3.25	2.13	9.21	30.50**
7.	RH 1569 × EC 597328	0.25	-0.62	-1.90	-0.08	0.12	-6.48	0.00	19.50**
8.	RH 1569 × EC 597317	-0.66	-1.16	-2.44	-0.62	15.04**	15.04*	23.01**	47.00**
9.	RH 1599-41 × RH 1222-28	-4.99	-13.22**	-12.01**	-10.38*	3.92	-4.76	-6.97	11.17
10.	RH 1599-41 × DRMR 2035	-2.02	-12.21**	-7.07	-5.34	-7.48	-17.78**	-13.95*	2.83
11.	RH 1599-41 × EC 597328	6.82	-0.43	-3.42	-1.63	14.84*	7.71	0.00	19.50**
12.	RH 1599-41 × EC 597317	4.38	-3.04	-5.25	-3.49	-8.32	-19.30**	-13.67*	3.17
13.	RH 1599-44 × RH 1222-28	-4.75	-4.97	-3.65	-1.86	23.17**	14.29*	11.58	33.33**
14.	RH 1599-44 × DRMR 2035	-11.74**	-13.80**	-8.76*	-7.06	11.19	0.00	4.60	25.00**
15.	RH 1599-44 × EC 597328	-1.55	-3.47	-2.59	-0.78	5.43	0.15	-6.97	11.17
16.	RH 1599-44 × EC 597317	-7.20	-8.67*	-7.83	-6.12	9.84	-2.17	4.60	25.00**
17.	RH 1633 × RH 1222-28	-0.21	-4.75	-3.42	-1.63	-6.05	-7.14	-9.34	8.33
18.	RH 1633 × DRMR 2035	-3.08	-9.34*	-4.03	-2.25	6.95	2.22	6.97	27.83**
19.	RH 1633 × EC 597328	-4.16	-6.54	-9.35*	-7.67	-8.55	-9.75	-13.95*	2.83
20.	RH 1633 × EC 597317	0.68	-2.18	-4.41	-2.64	3.42	-2.17	4.60	25.00**
21.	RH 1657 × RH 1222-28	-2.66	-6.98	-5.69	-3.93	16.58**	16.50*	13.95*	36.17**
22.	RH 1657 × DRMR 2035	-10.55**	-16.23**	-11.33**	-9.68*	5.72	2.27	6.97	27.83**
23.	RH 1657 × EC 597328	1.03	-1.37	-4.33	-2.56	0.05	-2.47	-4.60	14.00
24.	RH 1657 × EC 597317	1.52	-1.25	-3.50	-1.71	-20.55**	-23.96**	-18.69**	-2.83
25.	RH 1658 × RH 1222-28	-3.55	-13.00**	-11.79**	-10.15*	11.66	2.38	0.00	19.50**
26.	RH 1658 × DRMR 2035	-8.85*	-19.32**	-14.60**	-13.01**	-4.97	-15.51*	-11.58	5.67
27.	RH 1658 × EC 597328	0.11	-7.88	-10.65**	-8.99*	30.74**	22.68**	13.95*	36.17**
28.	RH 1658 × EC 597317	2.59	-5.92	-8.06*	-6.35	-3.73	-15.22*	-9.34	8.33
29.	RH 1664 × RH 1222-28	-1.26	-7.83	-6.54	-4.81	31.60**	19.10**	16.32**	39.00**
30.	RH 1664 × DRMR 2035	-8.32*	-16.09**	-11.18**	-9.53*	11.41	-2.18	2.37	22.33**
31.	RH 1664 × EC 597328	0.35	-4.35	-7.23	-5.50	29.80**	20.18**	11.58	33.33**
32.	RH 1664 × EC 597317	4.30	-0.94	-3.19	-1.39	2.52	-10.83	-4.60	14.00
33.	RH 1899-53 × RH 1222-28	1.05	-2.87	-1.52	0.31	-20.41**	-23.87 **	-18.55**	-2.67
34.	RH 1899-53 × DRMR 2035	-4.64	-10.20*	-4.94	-3.17	-1.10	-2.17	4.60	25.00**
35.	RH 1899-53 × EC 597328	4.34	2.47	-0.61	1.24	-18.59**	-23.96**	-18.69**	-2.83
36.	RH 1899-53 × EC 597317	1.65	-0.53	-2.80	-0.99	-10.83*	-10.83	-4.60	14.00
37.	PM 26 × RH 1222-28	4.65	-12.48**	-11.27**	-9.62*	8.14	-4.76	-6.97	11.17
38.	PM 26 × DRMR 2035	-1.34	-18.89**	-14.14**	-12.55**	16.91**	0.00	4.60	25.00**
39.	PM 26 × EC 597328	9.20*	-7.01	-9.81*	-8.13*	11.29	0.20	-6.97	11.17
40.	PM 26 × EC 597317	6.52	-9.57*	-11.63**	-9.99*	-10.18	-23.87**	-18.55**	-2.67

*Significant at $P \leq 0.05$ and **Significant at $P \leq 0.01$

Table 4: Percent relative heterosis (RH), heterobeltiosis (HB) and standard heterosis for number of secondary branches per plant and main shoot length (cm) in Indian mustard

Sr. No.	Hybrids	Number of secondary branches per plant				Main shoot length (cm)			
		RH	HB	Standard heterosis over		RH	HB	Standard heterosis over	
				Check-I (RH 725)	Check-II (RH 0749)			Check-I (RH 725)	Check-II (RH 0749)
1.	RH 1566 × RH 1222-28	6.36	2.63	14.71	19.41*	1.86	-1.70	-3.13	-2.32
2.	RH 1566 × DRMR 2035	-1.64	-7.69	17.65*	22.47**	3.33	0.86	-2.92	-2.11
3.	RH 1566 × EC 597328	7.32	5.95	21.53**	26.52**	0.31	-0.14	-7.64	-6.87
4.	RH 1566 × EC 597317	-22.43**	-24.68**	-10.65	-6.98	18.73**	14.81**	5.22	6.10
5.	RH 1569 × RH 1222-28	36.41**	33.33**	45.12**	51.07**	20.27**	12.50**	10.86*	11.78**
6.	RH 1569 × DRMR 2035	6.24	-1.52	25.53**	30.68**	11.01**	4.98	1.05	1.89
7.	RH 1569 × EC 597328	13.16*	10.26	26.47**	31.66**	25.76**	21.22**	12.11**	13.05**
8.	RH 1569 × EC 597317	13.79*	9.09	29.41**	34.72**	14.25**	14.11**	-2.08	-1.26
9.	RH 1599-41 × RH 1222-28	-4.80	-11.38	6.88	11.27	-0.99	-6.91	4.18	5.05

10.	RH 1599-41 × DRMR 2035	-21.74**	-23.85**	-2.94	1.04	-4.72	-11.38**	-0.83	0.00
11.	RH 1599-41 × EC 597328	2.50	0.00	20.59**	25.54**	8.68*	-0.75	11.07*	12.00**
12.	RH 1599-41 × EC 597317	-9.82	-10.55	7.88	12.31	9.71*	-3.19	8.34	9.25*
13.	RH 1599-44 × RH 1222-28	26.67**	25.49**	30.41**	35.76**	9.01*	7.63	6.06	6.95
14.	RH 1599-44 × DRMR 2035	5.12	-5.38	20.59**	25.54**	-0.76	-0.87	-4.58	-3.79
15.	RH 1599-44 × EC 597328	-0.48	-6.00	7.82	12.25	19.16**	16.96**	12.33**	13.26**
16.	RH 1599-44 × EC 597317	-0.44	-7.42	9.82	14.33	4.60	-1.08	-5.00	-4.21
17.	RH 1633 × RH 1222-28	-6.13	-12.29*	4.94	9.25	-8.75*	-14.04**	-4.17	-3.37
18.	RH 1633 × DRMR 2035	-7.15	-10.00	14.71	19.41*	-8.14*	-14.42**	-4.58	-3.79
19.	RH 1633 × EC 597328	-12.96*	-14.75*	2.00	6.18	18.12**	8.05*	20.47**	21.47**
20.	RH 1633 × EC 597317	-10.28*	-10.65	6.88	11.27	8.48*	-4.12	6.90	7.79
21.	RH 1657 × RH 1222-28	14.77**	6.43	29.41**	34.72**	1.40	-1.06	-2.51	-1.69
22.	RH 1657 × DRMR 2035	-6.29	-8.45	16.71*	21.49**	12.08**	10.62*	6.48	7.36
23.	RH 1657 × EC 597328	17.00**	13.69*	38.24**	43.91**	21.52**	20.70**	13.15**	14.10**
24.	RH 1657 × EC 597317	-23.27**	-24.21**	-7.82	-4.04	1.51	-2.90	-8.97*	-8.21
25.	RH 1658 × RH 1222-28	-1.77	-7.50	8.82	13.29	24.05**	23.53**	22.76**	23.78**
26.	RH 1658 × DRMR 2035	-17.60**	-20.77**	1.00	5.14	-1.39	-2.94	-3.55	-2.74
27.	RH 1658 × EC 597328	18.99**	17.50**	38.24**	43.91**	17.31**	13.24 **	12.54**	13.48**
28.	RH 1658 × EC 597317	3.75	3.32	22.59**	27.62**	6.55	-0.84	-1.45	-0.63
29.	RH 1664 × RH 1222-28	40.10**	30.19**	35.29**	40.85**	16.35**	10.81 *	9.19*	10.10*
30.	RH 1664 × DRMR 2035	12.22 *	-4.62	21.59**	26.58**	9.01*	4.99	1.05	1.89
31.	RH 1664 × EC 597328	21.15**	7.69	23.53**	28.60**	8.04	6.10	-1.88	-1.06
32.	RH 1664 × EC 597317	-1.87	-14.03*	2.00	6.18	9.67*	7.49	-4.17	-3.37
33.	RH 1899-53 × RH 1222-28	-23.13**	-34.22**	-3.88	0.06	-4.28	-7.62	-8.97*	-8.21
34.	RH 1899-53 × DRMR 2035	-3.96	-10.09*	31.35**	36.74**	15.10**	12.36**	8.14	9.04*
35.	RH 1899-53 × EC 597328	-11.27*	-20.80**	15.71*	20.45*	22.00**	21.45**	12.33**	13.26**
36.	RH 1899-53 × EC 597317	-14.85**	-22.86**	12.71	17.33*	14.72**	10.93*	1.68	2.53
37.	PM 26 × RH 1222-28	8.10	4.53	8.65	13.10	6.73	6.06	5.85	6.73
38.	PM 26 × DRMR 2035	33.62**	17.69**	50.00**	56.15**	13.95**	11.92**	11.70**	12.63**
39.	PM 26 × EC 597328	20.37**	11.11	27.47**	32.70**	15.31**	11.08*	10.86*	11.78**
40.	PM 26 × EC 597317	-10.89	-18.99**	-3.88	0.06	9.91*	2.09	1.89	2.74

*Significant at $P \leq 0.05$ and **Significant at $P \leq 0.01$

Table 5: Percent relative heterosis (RH), heterobeltiosis (HB) and standard heterosis for number of siliquae on main shoot and siliqua length (cm) in Indian mustard

Sr. No.	Hybrids	Number of siliquae on main shoot				Siliqua length (cm)			
		RH	HB	Standard heterosis over		RH	HB	Standard heterosis over	
				Check-I (RH 725)	Check-II (RH 0749)			Check-I (RH 725)	Check-II (RH 0749)
1.	RH 1566 × RH 1222-28	4.10	2.17	-1.14	13.35*	9.44*	0.85	-8.00	1.63
2.	RH 1566 × DRMR 2035	-3.81	-6.15	-4.55	9.44	16.20**	13.33**	-12.84**	-3.72
3.	RH 1566 × EC 597328	-1.62	-4.17	-7.28	6.31	2.41	-1.68	-17.89**	-9.30
4.	RH 1566 × EC 597317	1.54	0.71	-2.56	11.73*	-0.22	-5.69	-18.53**	-10.00*
5.	RH 1569 × RH 1222-28	7.62	5.58	2.27	17.26**	0.34	-1.56	-6.74	3.02
6.	RH 1569 × DRMR 2035	0.15	-2.23	-0.56	14.01*	9.58*	-2.96	-8.00	1.63
7.	RH 1569 × EC 597328	25.61**	22.29**	18.46**	35.82**	-7.87*	-13.33**	-17.89**	-9.30
8.	RH 1569 × EC 597317	0.30	-0.58	-3.70	10.42	23.95**	18.44**	12.21**	23.95**
9.	RH 1599-41 × RH 1222-28	2.02	0.30	-6.53	7.17	-2.40	-7.62	-15.79**	-6.98
10.	RH 1599-41 × DRMR 2035	-0.15	-5.87	-4.26	9.77	7.13	1.64	-17.26**	-8.60
11.	RH 1599-41 × EC 597328	7.19	6.20	-2.56	11.73*	3.83	2.52	-14.32**	-5.35
12.	RH 1599-41 × EC 597317	-7.99	-10.46	-14.78**	-2.29	12.13**	8.94*	-5.89	3.95
13.	RH 1599-44 × RH 1222-28	11.41*	11.24	3.97	19.21**	4.22	-3.00	-11.58**	-2.33
14.	RH 1599-44 × DRMR 2035	-11.50*	-15.08**	-13.64**	-0.98	6.39	2.68	-19.37**	-10.93*
15.	RH 1599-44 × EC 597328	11.35*	10.33	3.12	18.23**	10.87**	7.56	-10.11*	-0.70
16.	RH 1599-44 × EC 597317	-13.57**	-14.34*	-18.48**	-6.53	9.83*	4.88	-9.47*	0.00
17.	RH 1633 × RH 1222-28	-12.79*	-13.95*	-17.62**	-5.55	12.38**	9.39*	-0.21	10.23*
18.	RH 1633 × DRMR 2035	-6.47	-9.22	-7.67	5.86	20.74**	11.46**	-3.79	6.28
19.	RH 1633 × EC 597328	10.00	7.72	3.12	18.23**	21.49**	19.51**	3.16	13.95**
20.	RH 1633 × EC 597317	5.65	5.34	0.85	15.63**	17.80**	17.80**	1.68	12.33*
21.	RH 1657 × RH 1222-28	-24.85**	-26.17**	-28.69**	-18.23**	15.43**	3.93	-5.26	4.65
22.	RH 1657 × DRMR 2035	-7.16	-9.50	-7.96	5.53	28.78**	28.72**	-5.89	3.95
23.	RH 1657 × EC 597328	14.03**	11.18	7.38	23.12**	15.70**	8.40	-9.47*	0.00
24.	RH 1657 × EC 597317	-25.03**	-25.58**	-28.12**	-17.59**	18.85**	9.67*	-5.26	4.65
25.	RH 1658 × RH 1222-28	7.56	1.82	-5.11	8.79	15.97**	11.55**	1.68	12.33*
26.	RH 1658 × DRMR 2035	-14.29**	-22.07**	-20.74**	-9.13	30.30**	21.67**	2.53	13.26**
27.	RH 1658 × EC 597328	13.31*	8.06	-0.85	13.68*	21.26**	20.75**	1.68	12.33*
28.	RH 1658 × EC 597317	-2.87	-8.95	-13.35*	-0.64	8.64*	7.32	-7.37	2.33

29.	RH 1664 × RH 1222-28	21.94**	10.97	3.41	18.57**	4.42	-0.69	0.42	10.93*
30.	RH 1664 × DRMR 2035	-2.39	-14.53**	-13.07*	-0.33	14.39**	-1.46	-0.42	10.00*
31.	RH 1664 × EC 597328	29.07**	18.28**	8.52	24.43**	-2.59	-11.04**	-10.11*	-0.70
32.	RH 1664 × EC 597317	6.29	-4.18	-8.81	4.55	-5.62	-12.50**	-11.58**	-2.33
33.	RH 1899-53 × RH 1222-28	14.60**	11.28	3.70	18.90**	11.62**	0.92	-8.00	1.63
34.	RH 1899-53 × DRMR 2035	-7.64	-13.96*	-12.49	0.33	21.38**	20.86**	-10.95*	-1.63
35.	RH 1899-53 × EC 597328	17.42**	14.87*	5.40	20.85**	14.29**	7.56	-10.11*	-0.70
36.	RH 1899-53 × EC 597317	5.59	1.49	-3.41	10.75	15.79**	7.32	-7.37	2.33
37.	PM 26 × RH 1222-28	9.06	6.40	-0.85	13.68*	14.50**	4.85	-4.42	5.58
38.	PM 26 × DRMR 2035	-2.09	-8.38	-6.82	6.84	29.18**	26.85**	-3.79	6.28
39.	PM 26 × EC 597328	7.40	5.57	-3.14	11.06	12.78**	7.56	-10.11*	-0.70
40.	PM 26 × EC 597317	-7.27	-10.45	-14.78**	-2.29	12.64**	5.77	-8.63*	0.93

*Significant at $P \leq 0.05$ and **Significant at $P \leq 0.01$

Table 6: Percent relative heterosis (RH), heterobeltiosis (HB) and standard heterosis for number of seeds per siliqua and 1000-seed weight (g) in Indian mustard

Sr. No.	Hybrids	Number of seeds per siliqua				1000-seed weight (g)			
		RH	HB	Standard heterosis over		RH	RH	Standard heterosis over	
				Check-I (RH 725)	Check-II (RH 0749)			Check-I (RH 725)	Check-II (RH 0749)
1.	RH 1566 × RH 1222-28	12.55**	5.48	8.42	1.27	1.77	-8.01**	-9.42**	-16.49**
2.	RH 1566 × DRMR 2035	22.54**	19.59**	7.47	0.38	10.56**	8.71**	-13.58**	-20.32**
3.	RH 1566 × EC 597328	0.98	-0.37	-8.01	-14.08**	-11.53**	-16.48**	-33.55**	-38.73**
4.	RH 1566 × EC 597317	8.40*	6.57	-0.88	-7.42	9.32**	9.18**	-13.26**	-20.03**
5.	RH 1569 × RH 1222-28	6.78*	5.95	8.89	1.71	-5.21**	-6.93**	-8.47**	-15.61**
6.	RH 1569 × DRMR 2035	19.03**	9.84*	11.13*	3.80	2.05	-7.64**	-12.46**	-19.29**
7.	RH 1569 × EC 597328	12.54**	7.63	8.89	1.71	-6.08**	-18.08**	-22.36**	-28.42**
8.	RH 1569 × EC 597317	4.45	0.25	1.43	-5.26	7.09**	-1.68	-6.71**	-13.99**
9.	RH 1599-41 × RH 1222-28	7.53*	6.72	11.34	3.99	2.17	-13.20**	-14.54**	-21.21**
10.	RH 1599-41 × DRMR 2035	12.75**	2.60	7.06	0.00	0.91	-4.37	-26.52**	-32.25**
11.	RH 1599-41 × EC 597328	16.00**	9.33*	14.05**	6.53	0.99	-0.30	-29.55**	-35.05**
12.	RH 1599-41 × EC 597317	24.06**	17.33**	22.40**	14.33**	7.52**	0.40	-20.45**	-26.66**
13.	RH 1599-44 × RH 1222-28	15.51**	11.43**	14.53**	6.98	-12.66**	-22.51**	-23.80**	-29.75**
14.	RH 1599-44 × DRMR 2035	29.22**	22.49**	16.97**	9.26*	7.65**	7.21*	-17.57**	-24.01**
15.	RH 1599-44 × EC 597328	6.48	4.72	0.00	-6.59	-6.27*	-9.71**	-31.15**	-36.52**
16.	RH 1599-44 × EC 597317	16.45**	14.93**	9.78*	2.54	12.81**	10.61**	-12.30**	-19.15**
17.	RH 1633 × RH 1222-28	-3.69	-7.31*	2.99	-3.80	12.74**	12.28**	10.54**	1.91
18.	RH 1633 × DRMR 2035	13.69**	0.61	11.81*	4.44	15.57**	3.27	0.80	-7.07**
19.	RH 1633 × EC 597328	12.37**	2.87	14.32**	6.79	-0.98	-14.68**	-16.77**	-23.27**
20.	RH 1633 × EC 597317	-8.87**	-16.29**	-6.99	-13.13	21.31**	9.93**	7.35**	-1.03
21.	RH 1657 × RH 1222-28	5.41	2.84	5.70	-1.27	-3.97	-15.64**	-16.93**	-23.42**
22.	RH 1657 × DRMR 2035	15.56**	8.33*	5.91	-1.08	5.14*	3.53	-20.45**	-26.66**
23.	RH 1657 × EC 597328	3.57	0.69	-1.56	-8.05	-1.5	-4.07	-28.59**	-34.17**
24.	RH 1657 × EC 597317	17.20**	14.35**	11.81*	4.44	-3.25	-6.18*	-25.56**	-31.37**
25.	RH 1658 × RH 1222-28	5.67	4.38	7.26	0.19	-2.11	-4.43*	-1.28	-8.98**
26.	RH 1658 × DRMR 2035	20.58**	11.74**	12.02*	4.63	1.27	-11.70**	-8.79**	-15.91**
27.	RH 1658 × EC 597328	14.71**	10.18*	10.45*	3.17	-0.49	-16.24**	-13.42**	-20.18**
28.	RH 1658 × EC 597317	9.37**	5.42	5.70	-1.27	5.16*	-7.06**	-3.99	-11.49**
29.	RH 1664 × RH 1222-28	4.63	2.12	10.25*	2.98	-1.17	-6.17**	-7.67**	-14.87**
30.	RH 1664 × DRMR 2035	13.68**	1.89	9.98*	2.73	0.84	-5.78*	-16.61**	-23.12**
31.	RH 1664 × EC 597328	14.10**	5.85	14.26**	6.72	-2.44	-12.28**	-22.36**	-28.42**
32.	RH 1664 × EC 597317	5.86	-1.47	6.38	-0.63	-18.48**	-22.70**	-31.63**	-36.97**
33.	RH 1899-53 × RH 1222-28	4.61	-0.70	2.04	-4.69	2.22	-15.26**	-16.61**	-23.12**
34.	RH 1899-53 × DRMR 2035	20.61**	16.18**	7.26	0.19	16.74**	7.55**	-17.41**	-23.86**
35.	RH 1899-53 × EC 597328	26.25**	26.25**	16.56**	8.88	15.42**	10.63**	-21.88**	-27.98**
36.	RH 1899-53 × EC 597317	9.43*	9.03*	1.36	-5.33	15.79**	5.17	-16.61**	-23.12**
37.	PM 26 × RH 1222-28	17.05**	13.96**	17.11**	9.38*	1.27	-15.91**	-17.25**	-23.71**
38.	PM 26 × DRMR 2035	15.58**	8.58*	5.70	-1.27	18.32**	9.22**	-16.13**	-22.68**
39.	PM 26 × EC 597328	12.16**	9.28*	6.38	-0.63	14.72**	10.18**	-22.20**	-28.28**
40.	PM 26 × EC 597317	22.46**	19.74**	16.56**	8.88	9.82**	-0.07	-20.77**	-26.95**

*Significant at $P \leq 0.05$ and **Significant at $P \leq 0.01$

Table 7: Percent relative heterosis (RH), heterobeltiosis (HB) and standard heterosis for seed yield per plant (g) and oil content (%) in Indian mustard

Sr. No.	Hybrids	Seed yield per plant (g)				Oil content (%)			
		RH	HB	Standard heterosis over		RH	HB	Standard heterosis over	
				Check-I (RH 725)	Check-II (RH 0749)			Check-I (RH 725)	Check-II (RH 0749)
1.	RH 1566 × RH 1222-28	21.13	14.40	-0.18	4.91	-0.22	-0.26	-3.25**	-0.34
2.	RH 1566 × DRMR 2035	36.84*	12.35	-1.97	3.02	3.49**	3.44**	0.25	3.27**
3.	RH 1566 × EC 597328	5.83	-6.58	-18.49	-14.34	2.84**	2.84**	-0.35	2.65**
4.	RH 1566 × EC 597317	11.26	5.76	-7.72	-3.02	1.18**	-0.66*	-0.10	2.91**
5.	RH 1569 × RH 1222-28	27.23*	18.91	6.10	11.51	-1.02**	-1.94**	-3.10**	-0.18
6.	RH 1569 × DRMR 2035	43.39**	16.70	4.13	9.43	2.39**	1.35**	0.15	3.17**
7.	RH 1569 × EC 597328	38.78**	21.33	8.26	13.77	-0.89**	-1.86**	-3.00**	-0.08
8.	RH 1569 × EC 597317	12.73	6.04	-5.39	-0.57	-2.55**	-3.40**	-2.85**	0.08
9.	RH 1599-41 × RH 1222-28	27.45*	23.61	-4.13	0.75	-1.27**	-2.59**	-2.93**	0.00
10.	RH 1599-41 × DRMR 2035	34.26*	18.72	-13.46	-9.06	-1.10**	-2.51**	-2.85**	0.08
11.	RH 1599-41 × EC 597328	25.96	20.69	-12.03	-7.55	-1.48**	-2.85**	-3.18**	-0.26
12.	RH 1599-41 × EC 597317	16.11	11.87	-12.03	-7.55	-3.04**	-3.48**	-2.93**	0.00
13.	RH 1599-44 × RH 1222-28	33.57*	32.18*	2.51	7.74	1.32**	0.00	-0.43	2.58**
14.	RH 1599-44 × DRMR 2035	66.04**	44.26**	9.55	15.13	2.51**	1.09**	0.65*	3.69**
15.	RH 1599-44 × EC 597328	51.45**	42.32**	8.08	13.58	1.70**	0.34	-0.10	2.91**
16.	RH 1599-44 × EC 597317	42.16**	39.73**	9.87	15.47	-3.17**	-3.65**	-3.10**	-0.18
17.	RH 1633 × RH 1222-28	13.31	4.93	-4.49	0.38	0.34	0.17	-2.85**	0.08
18.	RH 1633 × DRMR 2035	28.94*	4.14	-5.21	-0.38	0.52*	0.43	-2.75**	0.18
19.	RH 1633 × EC 597328	13.99	-1.18	-10.05	-5.47	0.22	0.09	-3.00**	-0.08
20.	RH 1633 × EC 597317	15.13	7.30	-2.33	2.64	-1.82**	-3.73**	-3.18**	-0.26
21.	RH 1657 × RH 1222-28	2.34	1.39	-21.36	-17.36	0.93**	-0.91**	-0.25	2.76**
22.	RH 1657 × DRMR 2035	40.22*	21.70	-7.36	-2.64	-1.69**	-3.56**	-2.93**	0.00
23.	RH 1657 × EC 597328	13.57	6.60	-18.85	-14.72	-1.31**	-3.15**	-2.50**	0.44
24.	RH 1657 × EC 597317	-1.16	-2.74	-23.52*	-19.62	-3.77**	-3.81**	-3.18**	-0.26
25.	RH 1658 × RH 1222-28	30.85*	24.43	7.00	12.45	0.47*	0.17	-2.85**	0.08
26.	RH 1658 × DRMR 2035	1.64	-16.08	-27.83*	-24.15*	0.65**	0.43	-2.75**	0.18
27.	RH 1658 × EC 597328	47.59**	31.11*	12.75	18.49	3.28**	3.01**	-0.18	2.84**
28.	RH 1658 × EC 597317	0.33	-3.97	-17.41	-13.21	-0.08	-2.16**	-1.60**	1.37**
29.	RH 1664 × RH 1222-28	52.29**	42.59**	10.59	16.23	0.17	0.00	-3.00**	-0.08
30.	RH 1664 × DRMR 2035	43.40*	31.03	-11.31	-6.79	0.17	0.09	-3.10**	-0.18
31.	RH 1664 × EC 597328	40.45**	39.52*	-5.57	-0.75	-0.04	-0.17	-3.25**	-0.34
32.	RH 1664 × EC 597317	26.13	17.35	-7.72	-3.02	-1.31**	-3.23**	-2.68**	0.26
33.	RH 1899-53 × RH 1222-28	-11.83	-17.67	-26.39*	-22.64*	-1.94**	-3.80**	-3.00**	-0.08
34.	RH 1899-53 × DRMR 2035	48.64**	20.88	8.08	13.58	-1.69**	-3.64**	-2.85**	0.08
35.	RH 1899-53 × EC 597328	24.37	8.63	-2.87	2.08	-1.73**	-3.64**	-2.85**	0.08
36.	RH 1899-53 × EC 597317	6.41	0.00	-10.59	-6.04	-3.52**	-3.64**	-2.85**	0.08
37.	PM 26 × RH 1222-28	9.36	1.39	-21.36	-17.36	-0.43	-0.77**	-3.75**	-0.85**
38.	PM 26 × DRMR 2035	75.04**	61.52**	7.00	12.45	3.80**	3.53**	0.25	3.27**
39.	PM 26 × EC 597328	35.49*	34.95	-9.87	-5.28	0.22	-0.09	-3.18**	-0.26
40.	PM 26 × EC 597317	40.52**	29.45	1.80	6.98	1.40**	-0.75**	-0.18	2.84**

*Significant at $P \le 0.05$ and **Significant at $P \le 0.01$

Conclusion

The cross combinations *viz*., RH 1658 × EC 597328,RH 1664 × RH 1222-28, RH 1599-44 × EC 597317 and RH 1599-44 × DRMR 2035 were the top four best performing hybrids based on their heterosis for seed yield and its component traits as well as oil content. These hybrids not only out-yielded to their parents, but also to the best available cultivar (RH 725) used as check. These cross-combinations can have potential to serve as commercial F_1 hybrids after transferring them in to suitable cytoplasmic genetic male sterility system.

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