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Original Research Article

Estimation of Heterosis for Seed Yield and Yield Attributing Traits in Indian Mustard (*Brassica juncea* L. Czern & Coss.)

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A B S T R A C T

The experimental materials comprised of 79 treatments (15 lines, 4 testers and 60 F1) in two environments E1 (timely sown) and E2 (late sown) of Indian mustard. Were grown at Genetics and Plant Breeding research form, Narendra Deva University of Agriculture and Technology, Narendra Nagar, Faizabad (U.P.) under timely shown during *rabi* 2012-13 to study genetic variability of yield and its component traits. Seed yield per plant had significant and positive association with biological yield per plant (0.880) followed by plant height (0.548), harvest index (0.466), number of siliquae on main raceme (0.274) and length of main raceme (0.202) but it had significant negative association with 1000-seed weight (-0.190). The estimates of genotypic correlation coefficient were generally, similar in sigh or nature but higher in magnitude than the corresponding phenotypic correlation coefficient. Grain yield per plant had strong and positive association with biological yield per plant, plant height, harvest index, number of siliquae on main raceme and length of main raceme at phenotypic and genotypic level. Thus biological yield per plant followed by plant height, harvest index, number of siliquae on main raceme and length of main raceme emerged as most important and strongest associate of grain yield across diverse environment. The study revealed that greater emphasis should be given to these characters for yield improvement.

Keywords

Brassica juncea, Indian mustard, Heterosis breeding

Introduction

Indian mustard or brown mustard (rai) was originally introduced from China into north-eastern India, from where it had spread to Afghanistan via Punjab, eastern Afghanistan, together with adjoining north-western India. It is predominantly cultivated in Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh and Gujarat. Its cultivation is also being extended to non-traditional areas of southern India. During 2012-13, the Indian mustard crop had an average productivity of 11.45q/ha and area was 5.92 million ha and production was 6.78 million tons in all over India. Nature always favours the plant populations having much variability in terms of adaptation across the years and locations.

Materials and Methods

The experimental materials for present study comprised of 120 treatments (15 lines, 4 testers and 60 F1) in two environments E1 (timely sown) and E2 (late sown) of Indian

mustard. Genotypes were grown in randomized block design with three replications at the present field experiment was conducted at the Research Farm of Genetics and Plant Breeding, N.D.U.A. & T., Kumarganj, Faizabad, (U.P.) during *Rabi* 2012-13. Recommended cultural practices were followed to raise a healthy crop. The observations were recorded on five randomly selected plants for thirteen quantitative characters *viz.,* days to 50 per cent flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, length of main raceme, number of siliqua on main raceme, seeds per siliquae, 1000-seed weight, seed yield per plant, biological yield per plant, harvest-index, oil content which were recorded on plot basis.

Estimation of heterosis

The magnitude of heterosis was worked out as per cent increase or decrease of F_1 hybrid over better parent and standard variety *viz.,* SV (NDR 8501) (Table 1). The desirable sca effects may not be of practical utility until and unless *per se* performance of the combinations is compared to that of respective better parent and with standard variety (SV). The heterosis breeding has been extensively utilized in improving yield particularly in allogamous crops. The exploitation of heterosis in Indian mustard has been limited due to its autogamous nature. For a successful hybrid breeding programme, it is essential that a significant heterosis must be available in the F_1 populations and that a method is available for commercial seed production economically. Significant level of heterosis with respect to seed yield and its component traits have been reported with hybrids showing greater advantage under adverse environmental conditions.

Seed yield per plant

Magnitude of heterosis over better parent for seed yield ranged from ranged from -40.22 (Narendra Swarna Rai 8 × NDRE 4) to 12.25 per cent (RH 58 × CS 54), with a mean of 12.34 per cent in E1 and in E2 it ranged from -54.36 (KM 9201 × Urvashi) to 40.30 per cent (NPJ 141 × CS 54), with a mean of 2.23 per cent. Five crosses in E1. Positive significant relative heterosis is preferred to select the genotypes for inclusion in the further breeding programme so that the trait can be utilized in development of new high yielding varieties. The ultimate aim of heterosis breeding is to gain the heterotic crosses for seed yield and other associated heterotic character. From the present study the high yielding cross combinations can be utilized in future breeding programmes for developing high seed yielding genotypes. Higher magnitude of heterotic response for seed yield in Indian mustard was also reported by Khulbe *et al.* (1998), Katiyar *et al.* (2000), Shanti Patil *et al.* (2005) and Gupta and Narayan (2005).

Days to 50 per cent flowering

Manifestation of heterosis was found in both positive and negative direction. The mean of heterosis over better parent and standard variety was 8.04 and -9.91 per cent in E1 and 7.35 and 9.76 per cent in E2, respectively. The heterosis over better parent ranged from -12.77 (RH 58 × NDER 4) to 27.91 per cent (RRN 702 × Urvashi) in E1 and -32.24 (PRB 2004-3 × Urvashi) to 32.37 per cent (RH 0737 × NDRE 4) in E2.

Out of 60 crosses, F_1's showed significant heterosis over better parent in negative direction in E1 i.e. RMM 09-3 × CS 54 (-12.24%), RH 58 × NDRE 4 (-12.77%), KM 9201 × NDRE 4 (-6.38%), KM 9201 × CS 54 (-10.20%) and PRB 2004-3 × CS 54 (-

12.24%). In E2 PRB 2004-3 × RGN 73 (-32.24%), Kargil Selection × CS 54 (-22.66%), RRN 702 × CS 54 (-18.23%), KMR 10-2 × CS 54 (-14.78%) and PRB 2004-3 × CS 54 (-14.78%). Negative heterosis is preferred for flowering as it indicates earliness in flowering. Early flowering is desirable for *Brassica* species as it offers longer duration for grain feeling and certainly cause early maturity and high seed yield. The crosses having significant negative heterosis can select for harnessing the economic values of the related traits in the further breeding programme. Nassimi *et al.* (2006) reported desirable negative significant better parent heterosis for days to 50 % flowering, in *Brassica* genotypes.

Days to maturity

Heterosis over better parent and standard varieties (SV) ranged from -7.63 (Parashmani 33 × NDRE 4) to 5.99 per cent (RH 58 × RGN 73) and from -6.92 (NPJ 141 × NDRE 4) per cent in E1and -3.08 (RH 58 × Urvashi) to 6.04 (RH 58 × CS 54), respectively. Early maturity is useful in most plant species especially *Brassica* where delayed maturity cause losses in yield and quality of oil due to high temperature (Turi *et al.*, 2006). Negative heterosis, therefore, is useful regarding days to maturity Nassimi *et al.* (2006). These results were well supported by similar findings of Yadava *et al.*, (2012) who reported desirable significant negative heterobeltiosis for days to maturity

Plant height

Heterosis over better parent ranged from -28.26 (Narendra Swarna Rai 8 × NDRE 4) to 13.89 per cent (Parashmani 33 × Urvashi) with an overall mean of 3.8 per cent in E1 and in E2 ranged from -24.63 (Basanti × Urvashi) to 16.77 per cent (Parashmani 33 × CS 54) with overall mean of 10.91 per cent. Short and medium plant height of *Brassica* species is desirable as it resist more towards the high wind velocity and hence, reduce the lodging and mechanical breakage. So, negative heterosis is desirable regarding plant height. Desirable negative and significant heterosis for plant height has been earlier reported by Tyagi *et al.*, 2000, Pourdad and Sachan (2003) and Nassimi *et al.* (2006).

Number of primary branches per plant

The estimates of heterosis over BP ranged from -39.39 (KMR 9201 × NDRE 4) to 25.74 per cent (KMR 10-1 × RGN 73) with over all mean of 8.97 per cent in E1 and in E2 it ranged from -34.42 (Basanti × Urvashi) to 22.06 per cent (Parashmani 33 × Urvashi) with over all mean of 5.96 per cent. Five crosses in E1 and one cross in E2 showed significant and positive heterosis over better parent. In *Brassica*, positive heterosis for number of primary branches is desirable, because plants with vigorous stature containing more branches provide opportunity for higher yields. Earlier, Gupta (2009) reported desirable positive heterobeltiosis for primary branches plant-1. Also, significant positive heterobeltiosis for number of primary branches plant -1 was also reported by Nasrin *et al.* (2011).

Number of secondary branches per plant

The mean value of heterosis in per cent showed 11.68 in E1 and 16.03 in E2 over BP; and 8.64 in E1 and 9.05 in E2 over SV, respectively. The better parent heterosis varied from -75.21 (KMR 10-2 × NDRE 4) to 68.85 (RH 58 × RGN 73) in E1 and in E2 it ranged from -56.03 (RH 0737 × CS 54) to 102.19 (Narendra Swarna Rai 8) per cent. Short stature with vigorous structure containing more branches will provide high

yield opportunity, so positive heterosis is desirable for number of secondary branches. Niranjana *et al.* (2014) earlier reported positive significant heterosis for secondary branches per plant.

Length of main raceme (cm)

Heterosis over better parent ranged from -27.32 (KM 9201 × NDRE 4) to 65.79 per cent (Kargil Selection × CS 54) with an overall mean of 1.44 per cent in E1 and in E2 it ranged from -38.28 (RRN 702 × NDRE 4) to 26.57 per cent (Parashmani 33 × NDRE 4) with an overall mean of 0.73 per cent.

Number of siliquae on main raceme

Significant and positive standard heterosis over SV (NDR 8501) crosses displayed by the crosses zero in E1 and NPJ 141 × Urvashi (18.07) and ACN 83 × RGN 73 (23.66) in E2. Out of sixty cross combinations, none in E1 and two in E2 showed significant and positive heterosis over SV. The range of heterosis for SV and from -34.97 (NPJ 141 × CS 54) to 0.56 per cent (Basanti × Urvashi) in E1 and in E2 it ranged from -41.41 (PRB 2004-3 × NDRE 4) to 23.66 per cent (ACN 83 × RGN 73), respectively. More number of siliqua in main raceme is desirable trait in the *Brassica* species for harvesting high seed yield, so positive heterosis is desirable for this trait.

Number of seeds per siliqua

The mean heterosis over better parent and standard variety (NDR 8501) was 1.85 and 5.49 per cent in E1 and 2.93 and 11.20 per cent in E2. The magnitude of better parent heterosis varied from -20.26 (ACN 83 × Urvashi) to 24.81 (Kargil Selection × RGN 73) per cent in E1 and from -14.91 (Narendra Swarna Rai 8 × Urvashi) to 18.28 (KMR 10-1 × Urvashi) per cent in E2. Significant and positive heterosis over better parent was displayed by Kargil Selection × RGN 73 (24.81%), Basanti × CS 54 (18.30%), Narendra Swarna Rai 8 × CS 54 (15.03%), Kargil Selection × CS 54 (14.21%) and RH 0737 × Urvashi (13.53%) in E1 and RRN 702 × NDRE 4 (18.28%), RH 58 × CS 54 (17.53%), Parashmani 33 × RGN 73 (13.67%), NPJ 141 × Urvashi (12.94%) and Kargil Selection × NDRE 4 (12.50%) in E2. Number of seed per siliqua characters has a direct correlation with the seed yield as its alteration definitely change the seed yield per plant. So, positive heterosis is desirable regarding number of seeds per siliqua

1000-seed weight (g)

The heterosis over BP ranged from -40.22 (Narendra Swarna Rai 8 × NDRE 4) to 12.25 per cent (RH 58 × CS 54), with a mean of 12.34 per cent in E1 and in E2 it ranged from -54.36 (KM 9201 × Urvashi) to 40.30 per cent (NPJ 141 × CS 54), with a mean of 2.23 per cent.

Seed yield per plant

Crosses differed considerably in their heterotic response and ranged from -47.72 (KMR 10-2 × NDRE 4) to 36.86 per cent (Kargil Selection × CS 54) in E1 and from -48.43 (NDR 8501 × NDRE 4) to 44.48 per cent (Kargil Selection × Urvashi) in E2 over BP and from -47.48 (KM 9201 × CS 54) to 25.68 per cent (PRB 2004-3 × NDRE 4) in E1 and from -48.43 (NDR 8501 × NDRE 4) to 44.48 per cent (Kargil Selection × Urvashi) in E2 over SV (NDR 8501).

Higher magnitude of heterotic response for seed yield in Indian mustard was also reported by Khulbe *et al.* (1998), Katiyar *et*

al. (2000), Shanti Patil *et al.* (2005) and Gupta and Narayan (2005).

Biological yield per plant

The heterosis over better parent ranged from -43.38 (KMR 10-2 × RGN 73) to 72.49 per cent (RH 58 × CS 54) with a mean of 7.71 per cent in E1 and from -41.23 (NDR 8501 × NDRE 4) to 93.46 per cent (Kargil Selection × RGN 73) with a mean of 5.11 per cent in E2.

Harvest index

For this character heterosis ranged from -33.20 (RH 58 × RGN 73) to 20.01 per cent (KMR 10-2 × RGN 73) in E1 and from -32.74 (Kargil Selection × NDRE 4) to 19.67 (RH 58 × NDRE 4) in E2 with overall mean value of 9.38 per cent in E1 and 11.46 per cent in E2 over BP and from -11.53 (KM 9201 × CS 54) to 38.89 per cent (RH0737 × RGN 73) in E1 and from -24.14 (RMM 09-3 × RGN 73) to 17.06 per cent (RNN 702 × Urvashi) in E2 with overall mean value of 11.58 in E1 and 11.17 per cent in E2 over SV (NDR 8501) exhibited significant positive heterosis for harvest index.

Oil content (%)

Crosses differed considerably in their heterotic response and ranged from -5.22 (ACN 83 × CS 54) to 2.16 per cent (Parshmani-33 × NDRE 4) in E1 and from -5.75 (Narendra Swaarna Rai 8 × CS 54) 3.79 per cent (Parshmani 33 × CS 54) in E2. exhibited significant positive heterosis for oil content showed heterosis over SV in desirable direction.

Manifestation of considerable heterosis for such yield components have been reported earlier by Ghosh *et al.* (2002), Goswami *et al.* (2004), Shanti Patil *et al.* (2005) and Singh *et al.* (2007).

Results and Discussion

The heterosis breeding has been extensively utilized in improving yield particularly in allogamous crops. The exploitation of heterosis in Indian mustard has been limited due to its autogamous nature. For a successful hybrid breeding programme, it is essential that a significant heterosis must be available in the F_1 populations and that a method is available for commercial seed production economically. Significant level of heterosis with respect to seed yield and its component traits have been reported with hybrids showing greater advantage under adverse environmental conditions. In the present investigation, magnitude of heterosis over better parent for seed yield ranged from ranged from -40.22 (Narendra Swarna Rai 8 × NDRE 4) to 12.25 per cent (RH 58 × CS 54), with a mean of 12.34 per cent in E1 and in E2 it ranged from -54.36 (KM 9201 × Urvashi) to 40.30 per cent (NPJ 141 × CS 54), with a mean of 2.23 per cent. Higher magnitude of heterotic response for seed yield in Indian mustard was also reported by Khulbe *et al.* (1998), Katiyar *et al.* (2000), Shanti Patil *et al.* (2005) and Gupta and Narayan (2005).

A perusal revealed that heterosis in seed yield was proportional to the heterosis observed for yield components. In majority of cases heterosis in most of the components registered heterosis for seed yield. The top five crosses showing significant heterobeltiosis for seed yield were also found to register significant positive heterobeltiosis for number of siliquae on main raceme, number of seeds per siliqua, 1000-seed weight, harvest index and oil content in E1 & E2. However, top five crosses, which showed positive heterosis over SV for seed yield, were also having positive and significant standard heterosis in E1 & E2 for all characters studied.

Table.1 Extent of per cent heterosis over better parent (BP) and standard varieties i.e. NDR 8501 (SV) for 13 characters in Indian mustard

S. No.	Crosses	Days to 50% flowering				Days to maturity				Plant height			
		E1		E2		E1		E2		E1		E2	
		BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
1	NPJ 141 x NDRE 4	0.00	-14.55**	19.30**	-9.33**	-6.20**	-6.92**	2.54**	-1.09	-16.75**	-23.29**	-12.36**	-12.07**
2	NPJ 141 x CS 54	4.08*	-7.27**	25.73**	-4.44*	-0.78	-1.54*	-3.06**	-5.16**	-13.73**	-20.51**	4.60	4.95
3	NPJ 141 x RGN 73	22.22**	0.00	0.58	-23.56**	0.00	-1.54*	0.83	-1.36	-4.43**	-7.59**	14.51**	14.88**
4	NPJ 141 x Urvashi	18.60**	-7.27**	9.94**	-16.44**	1.31	-1.03	4.48**	1.36	-12.29**	-19.19**	-4.65	-4.34
5	RH0737 x NDRE 4	4.26*	-10.91**	32.37**	1.78	-7.63**	-6.92**	0.56	-2.99**	-17.77**	-19.73**	-4.02	-8.39**
6	RH0737 x CS 54	6.12**	-5.45**	4.05	-20.00**	-0.26	-0.77	2.16*	2.99**	-13.12**	-15.19**	8.13**	3.20
7	RH0737 x RGN 73	15.56**	-5.45**	22.54**	-5.78**	1.04	-0.51	4.96**	3.53****	6.55**	4.01*	-6.20*	-7.95**
8	RH0737 x Urvashi	18.60**	-7.27**	13.29**	-12.89**	0.00	-2.31**	0.84	-2.17*	-9.79**	-11.94**	-4.21	-7.39**
9	KMR 10-2 x NDRE 4	0.00	-14.55**	26.44**	-2.22	-6.87**	-6.15**	2.54**	-1.09	-19.06**	-25.02**	-19.16**	-9.78**
10	KMR 10-2 x CS 54	6.12**	-5.45**	-14.78**	-23.11**	-0.26	-0.77	1.08	1.90*	6.26**	-1.57	-4.30	6.80*
11	KMR 10-2 x RGN 73	22.22**	0.00	1.82	-0.44	-1.56*	-3.08**	3.31**	1.90*	-3.91	-7.08**	-7.13**	3.64
12	KMR 10-2 x Urvashi	18.60**	-7.27**	11.96**	-8.44**	0.79	-1.54*	5.88**	2.72**	5.09*	-2.66	-2.60	8.69**
13	Parashmani 33 x NDRE 4	6.38**	-9.09**	29.89**	0.44	-7.63**	-6.92**	1.97*	-1.63	-17.04**	-29.92**	7.74*	-19.00**
14	Parashmani 33 x CS 54	10.20**	-1.82	13.19**	-8.44**	-3.35**	-3.85**	3.58**	2.17*	12.55**	-3.94*	16.77**	8.96**
15	Parashmani 33 x RGN 73	8.89**	-10.91**	17.03**	-5.33**	0.00	-1.54*	0.00	-1.36	-6.39**	-9.49**	1.80	-0.11
16	Parashmani 33 x Urvashi	25.58**	-1.82	-1.10	-20.00**	0.52	-1.79*	5.60**	2.45**	13.89**	-3.14	6.06*	2.55
17	KMR 10-1 x NDRE 4	2.13*	-12.73**	24.71**	-3.56	-6.87**	-6.15**	3.10**	-0.54	-2.67	-8.94**	-5.84*	-10.13**
18	KMR 10-1 x CS 54	6.12**	-5.45**	6.90**	-3.56	-4.90**	-5.38**	2.16*	2.99**	-0.21	-6.65**	5.34	0.54
19	KMR 10-1 x RGN 73	11.11**	-9.09**	2.24	1.33	0.00	-1.54*	3.31**	1.90*	0.13	-3.18	8.79**	6.76*
20	KMR 10-1 x Urvashi	16.28**	-9.09**	13.04**	-7.56**	0.79	-1.54*	3.92**	0.82	0.35	-6.12**	12.01**	8.30**
21	RRN 702 x NDRE 4	-2.13	-16.36**	24.14**	-4.00*	-7.38**	-6.67**	2.25*	-1.36	-5.07*	-16.78**	-6.56*	-12.46**
22	RRN 702 x CS 54	6.12**	-5.45**	-18.23**	-26.22**	-1.80*	-2.31**	1.08	1.90*	8.45**	-4.93*	3.30	-3.23
23	RRN 702 x RGN 73	11.11**	-9.09**	1.37	-1.33	0.00	-1.54*	2.20*	0.82	0.84	-2.49	9.33**	7.28**
24	RRN 702 x Urvashi	27.91**	0.00	11.41**	-8.89**	1.57*	-0.77	0.00	-2.99**	2.37	-10.26**	-9.49**	-12.49**
25	ACN 83 x NDRE 4	0.00	-14.5**5	24.71**	-3.56	-0.53	-3.08**	-1.13	-4.62**	-19.64**	-28.60**	0.40	-17.24**
26	ACN 83 x CS 54	0.00	-10.91**	-3.45	-12.89**	2.63**	0.00	0.27	-0.54	1.59	-9.74**	4.67	-2.33
27	ACN 83 x RGN 73	4.44*	-14.55**	0.95	-5.78**	1.84*	-0.77	3.31**	1.90*	-12.84**	-15.72**	10.73**	8.65**
28	ACN 83 x Urvashi	18.60**	-7.27**	-8.15**	-24.89**	1.84*	-0.77	0.56	-2.45**	-11.79**	-21.63**	6.15*	2.64
29	NDR 8501 x NDRE 4	0.00	-14.55**	17.24**	-9.33**	-0.77	-0.77	1.41	-2.17*	-10.26**	-10.26**	-17.37**	-17.37**
30	NDR 8501 x CS 54	10.20**	-1.82	3.94	-6.22**	-2.58**	-3.08**	1.63	1.63	1.95	1.95	2.85	2.85

31	NDR 8501 x RGN 73	17.78**	-3.64**	-8.97**	-9.78**	-1.56*	-3.08**	2.48**	1.09	-9.83**	-9.83**	3.57	3.57
32	NDR 8501 x Urvashi	20.93**	-5.45**	4.89*	-14.22**	0.79	-1.54*	1.96*	-1.09	-10.30**	-10.30**	0.07	0.07
33	Kargil Selection x NDRE 4	0.71	-13.94**	22.41**	-5.33**	0.78	0.00	3.94**	0.27	11.26**	-10.71**	-4.61	-14.36**
34	Kargil Selection x CS 54	4.08*	-7.27**	-22.66**	-30.22**	-3.10**	-3.85**	-0.81	0.00	11.43**	-4.90*	8.85**	1.57
35	Kargil Selection x RGN 73	20.00**	-1.82	-3.21	-6.22**	1.56*	0.00	0.83	-0.54	-7.46**	-10.51**	9.99**	7.93**
36	Kargil Selection x Urvashi	13.95**	-10.91**	2.17	-16.44**	2.36**	0.00	1.68	-1.36	3.40	-12.07**	-6.92*	-10.00**
37	Basanti x NDRE 4	0.00	-14.55**	17.24**	-9.33**	-1.54*	-1.54*	1.41	-2.17*	-1.98	-7.66**	-24.63**	-17.37**
38	Basanti x CS 54	4.08*	-7.27**	12.32**	1.33	-3.35**	-3.85**	2.43**	3.26**	-2.47	-8.13**	-4.05	5.19
39	Basanti x RGN 73	17.78**	-3.64*	-3.59	-4.44*	-0.78	-2.31**	0.00	-1.36	-1.07	-4.34*	1.43**	11.20**
40	Basanti x Urvashi	25.58**	-1.82	20.11**	-1.78	1.57*	-0.77	0.84	-2.17*	4.30*	-1.75	-15.38**	-7.23**
41	Narendra Swarna Rai 8 x NDRE 4	-2.13	-16.36**	9.20**	-15.56**	-3.82**	-3.08**	-2.82**	-6.25**	-28.26**	-30.79**	-8.60**	-13.60**
42	Narendra Swarna Rai 8 x CS 54	10.20**	-1.82	5.42*	-4.89*	-1.03	-1.54*	3.23**	4.08**	-10.00**	-13.17**	12.24**	6.10*
43	Narendra Swarna Rai 8 x RGN 73	20.00**	-1.82	-9.72**	-13.33**	-0.78	-2.31**	-1.65	-2.99**	-3.34	-6.54**	6.93*	4.92
44	Narendra Swarna Rai 8 x Urvashi	18.60**	-7.27**	7.61**	-12.00**	2.36**	0.00	3.36**	0.27	-11.80**	-14.91**	8.20**	4.62
45	RMM 09-3 x NDRE 4	0.00	-14.55**	22.41**	-5.33**	-1.27	-0.51	3.94**	0.27	1.54	-11.92**	-18.73**	-6.95*
46	RMM 09-3 x CS 54	-12.24**	-21.82**	-2.46	-12.00**	-2.58**	-3.08**	-1.89*	-1.36	-1.19	-14.29**	-7.75**	5.62*
47	RMM 09-3 x RGN 73	-2.22	-20.00**	-4.19*	-8.44**	-0.78	-2.31**	1.65	0.27	-5.83**	-8.94**	-9.55**	3.55
48	RMM 09-3 x Urvashi	16.28**	-9.09**	-14.67**	-30.22**	0.00	-2.31**	1.68	-1.36	11.04**	-3.69	-17.59**	-5.64*
49	RH 58 x NDRE 4	-12.77**	-25.45**	24.14**	-4.00*	-1.56*	-3.08**	-2.54**	-5.98**	-27.65**	-29.65**	-22.20**	-15.93**
50	RH 58 x CS 54	6.12**	-5.45**	-2.46	-12.00**	-1.56*	-3.08**	6.04**	4.89**	6.45**	3.50	3.35	11.68**
51	RH 58 x RGN 73	-2.22	-20.00**	-3.21	-6.22**	5.99**	4.36**	-0.55	-1.90*	-7.58**	-10.14**	-2.24	5.64*
52	RH 58 x Urvashi	3.88*	-18.79**	17.39**	-4.00*	0.79	-1.54*	-3.08**	-5.98**	-3.90	-6.56**	-23.19**	-17.00**
53	KM 9201 x NDRE 4	-6.38**	-20.00**	31.03**	1.33	-2.56**	-2.56**	2.25*	-1.36	-10.87**	-21.21**	-3.83	-8.61**
54	KM 9201 x CS 54	-10.20**	-20.00**	-5.91**	-15.11**	-2.58**	-3.08**	3.54**	3.26**	4.21	-7.88**	3.62	-1.53
55	KM 9201 x RGN 73	8.89**	-10.91**	-3.60	-4.89*	0.00	-1.54*	0.83	-0.54	-4.82*	-7.97**	1.91	0.00
56	KM 9201 x Urvashi	6.98**	-16.36**	18.48**	-3.11	0.79	-1.54*	0.00	-2.99**	-10.79**	-21.14**	-20.42**	-23.06**
57	PRB 2004-3 x NDRE 4	-4.26*	-18.18**	31.03**	1.33	0.00	0.00	2.82**	-0.82	-0.56	-13.08**	-11.93**	-10.90**
58	PRB 2004-3 x CS 54	-12.24**	-21.82**	-14.78**	-23.11**	-1.03	-1.54*	1.11	-1.36	2.36	-10.53**	3.77	4.99
59	PRB 2004-3 x RGN 73	13.33**	-7.27**	-32.24**	-35.56**	1.56*	0.00	3.62**	1.09	5.85**	2.35	-2.24	-1.09
60	PRB 2004-3 x Urvashi	18.60**	-7.27**	13.59**	-7.11**	2.36**	0.00	2.52**	-0.54	5.02*	-8.20**	-9.80**	-8.74**
	Mean	8.97	1.44	5.96	10.87	11.68	8.64	16.03	9.50	1.44	11.10	0.73	1.02
	C.D at 5%	0.81		1.04		1.35		1.51		5.99		5.48	

S. No.	Crosses	No. of primary branches per plant				No. of secondary branches per plant				Length of main raceme (cm)			
		E1		E2		E1		E2		E1		E2	
		BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
1	NPJ 141 x NDRE 4	-22.73**	10.87	-13.37	8.00	-36.62**	12.50	-13.55**	17.54**	-0.74	-6.38	-29.14**	-17.88**
2	NPJ 141 x CS 54	-13.33	-5.80	-13.12	-7.33	3.10	33.00**	33.33**	-6.43	-10.30*	-15.40**	5.72	22.51**
3	NPJ 141 x RGN 73	11.90	2.17	1.64	24.00**	67.74**	56.00**	13.75	-20.18**	12.05**	5.68	-6.53	8.32
4	NPJ 141 x Urvashi	-2.33	-8.70	11.35	4.67	-9.33	2.00	20.63*	-11.11	5.11	-0.87	-3.79	11.49*
5	RH0737 x NDRE 4	-33.33**	-4.35	-11.34	14.67	-26.48**	30.50**	-31.18**	-6.43	-20.76**	-15.53**	18.98**	15.36**
6	RH0737 x CS 54	-26.67**	-20.29*	-27.32**	-6.00	-42.25**	-25.50*	-56.03**	-52.05**	-17.62**	-12.19**	-8.22	-7.68
7	RH0737 x RGN 73	-13.33	-15.22	-13.40	12.00	-22.95*	-29.50**	-35.66**	-29.82**	-17.46**	-12.02**	5.83	3.22
8	RH0737 x Urvashi	10.37	7.97	-10.31	16.00	-26.67**	-17.50	4.56	14.04*	-19.78**	-14.49**	-0.99	-0.41
9	KMR 10-2 x NDRE 4	-34.34**	-5.80	-11.76	10.00	-75.21**	-56.00**	-0.65	35.09**	-9.69*	-27.25**	2.48	-0.64
10	KMR 10-2 x CS 54	-13.33	-5.80	-8.06	14.00	-34.88**	-16.00	96.10**	17.54**	12.76*	-9.15*	7.69	8.32
11	KMR 10-2 x RGN 73	9.09	4.35	-3.23	20.00	-12.02	-19.50	37.99**	-7.60	-3.26*	-11.24**	0.24	-2.23
12	KMR 10-2 x Urvashi	15.91	10.87	-1.08	22.67*	-8.00	3.50	12.70	-16.96*	9.46	-11.11**	-5.71	-5.16
13	Parashmani 33 x NDRE 4	20.20**	72.46**	18.72*	48.00**	10.70	96.50**	-20.65**	7.89	2.65	-19.44**	9.01	5.69
14	Parashmani 33 x CS 54	-37.64**	-19.57*	8.75	16.00	-52.33**	-38.50**	90.55**	-29.24**	23.55**	-3.04	26.57**	27.32**
15	Parashmani 33 x RGN 73	-27.53**	-6.52	0.00	22.00*	9.84	0.50	58.52**	6.14	-3.26	-11.24**	-7.03	-9.32
16	Parashmani 33 x Urvashi	-19.10**	4.35	22.06	10.67	8.00	21.50*	37.70**	1.46	-11.00*	-27.72**	7.28	7.91
17	KMR 10-1 x NDRE 4	-24.24**	8.70	-0.53	24.00*	-39.15**	8.00	-19.35**	9.65	11.53*	-14.36**	-5.31	2.34
18	KMR 10-1 x CS 54	-14.67	-7.25	-8.06	14.00	-24.81**	-3.00	75.42**	21.05**	18.02**	-9.37*	6.24	14.83**
19	KMR 10-1 x RGN 73	25.74**	23.91**	-2.69	20.67	56.28**	43.00**	61.02**	11.11	-0.99	-9.15*	-1.08	6.92
20	KMR 10-1 x Urvashi	-9.56	-10.87	-0.54	23.33*	-46.67**	-40.00**	-18.65**	-40.06**	10.79*	-10.02*	-6.78	0.76
21	RRN 702 x NDRE 4	-24.24**	8.70	-5.88	17.33	-19.72**	42.50**	-31.18**	-6.43	9.94*	-9.80*	-38.28**	-39.04**
22	RRN 702 x CS 54	6.67	15.94	0.61	10.00	-37.21**	-19.00	-6.63	-5.26	-2.86	-20.30**	11.19*	11.84**
23	RRN 702 x RGN 73	-20.71*	-19.57*	13.11	38.00**	-27.32**	-33.50**	4.61	6.14	-2.88	-10.89**	0.77	-0.47
24	RRN 702 x Urvashi	-5.71	-4.35	-30.49**	-24.00*	-10.67	0.50	-53.60**	-52.92**	8.04	-11.37**	-3.26	-2.70
25	ACN 83 x NDRE 4	-18.18**	17.39	-22.99**	-4.00	-18.31**	45.00**	-18.71**	10.53	-3.65	-27.77**	3.03	17.47**
26	ACN 83 x CS 54	14.67	24.64*	-26.88**	-22.00	23.26**	59.00**	13.70	-27.19**	16.38**	-12.75**	-4.99	8.32
27	ACN 83 x RGN 73	8.66	0.00	-1.64	20.00	15.14	6.50	32.31**	-11.40	-11.21*	-18.52**	4.83	19.52**

28	ACN 83 x Urvashi	-2.33	-8.70	14.71	4.00	-11.11	0.00	5.56	-22.22**	-8.81	-25.94**	-14.86**	-2.93
29	NDR 8501 x NDRE 4	-28.79**	2.17	-5.35	18.00	-35.77**	14.00	-13.55**	17.54**	-6.55	-6.55	-12.25*	-12.25*
30	NDR 8501 x CS 54	-13.33	-5.80	-4.37	2.00	3.88	34.00**	0.00	0.00	-0.22	-0.22	8.57	9.20
31	NDR 8501 x RGN 73	-21.74*	-21.74*	-22.95**	-6.00	-64.00**	-64.00**	-16.37*	-16.37*	-15.53**	-15.53**	3.81	3.81
32	NDR 8501 x Urvashi	-8.70	-8.70	11.33	11.33	-26.67**	-17.50	-6.73	-6.73	-5.64	-5.64	-2.74	-2.17
33	Kargil Selection x NDRE 4	-28.79**	2.17	9.09	36.00**	-28.45**	27.00**	-36.34**	-13.45*	26.60**	-8.33*	-4.41	-7.33
34	Kargil Selection x CS 54	-4.00	4.35	-7.27	2.00	0.39	29.50**	-14.12	-35.96**	65.79**	-10.02*	-5.89	-5.33
35	Kargil Selection x RGN 73	11.90	2.17	6.56	30.00**	50.27**	37.50**	55.69**	16.08*	-6.71	-14.40**	11.24*	8.50
36	Kargil Selection x Urvashi	23.26*	15.22	3.64	14.00	14.67	29.00**	46.67**	9.36	22.49**	-0.52	-10.20*	-9.67*
37	Basanti x NDRE 4	-18.18**	17.39	-17.67*	18.00	-8.73	62.00**	-13.55**	17.54**	31.01**	5.03	-9.01	-11.78*
38	Basanti x CS 54	-13.33	-5.80	-26.05**	6.00	-48.06**	-33.00**	1.33	-33.33**	-0.43	-20.17	2.27	2.87
39	Basanti x RGN 73	16.67	6.52	-10.23	28.67**	19.67	9.50	20.52*	-19.30**	-13.66**	-20.78**	13.76**	10.96*
40	Basanti x Urvashi	-2.33	-8.70	-34.42**	-6.00	-6.67	5.00	38.49**	2.05	32.85**	7.90**	-3.44	-2.87
41	Narendra Swarna Rai 8 x NDRE 4	-21.21**	13.04	-14.97	6.00	0.56	78.50**	-44.52**	-24.56**	-20.71**	-22.60**	-23.16**	-25.50**
42	Narendra Swarna Rai 8 x CS 54	-6.67	1.45	11.83	26.00*	-9.30	17.00	102.19**	34.80**	-11.47**	-13.58**	6.88	7.50
43	Narendra Swarna Rai 8 x RGN 73	20.00*	17.39	-11.48	8.00	1.09	-7.50	6.55	-28.65**	-3.02	-5.34	17.55**	14.65**
44	Narendra Swarna Rai 8 x Urvashi	-8.89	-10.87	-14.79	-4.00	8.00	21.50*	21.83*	-10.23	-8.00*	-10.20*	3.44	4.04
45	RMM 09-3 x NDRE 4	-7.58	32.61**	-3.74	20.00	-7.89	63.50**	-47.96**	-29.24**	2.60	-12.54**	-1.67	-3.40
46	RMM 09-3 x CS 54	-8.00	0.00	-4.07	10.00	-21.71**	1.00	-14.69	-38.89**	-2.65	-17.01**	-12.35*	-11.84*
47	RMM 09-3 x RGN 73	-4.55	-8.70	-8.20	12.00	1.64	-7.00	60.41**	14.91*	-11.39**	-18.70**	-1.61	-3.34
48	RMM 09-3 x Urvashi	6.82	2.17	1.74	16.67	2.22	15.00	-10.71	-34.21**	1.42	-13.54**	-15.68**	-15.18**
49	RH 58 x NDRE 4	-25.76**	6.52	-27.81**	-10.00	-26.20**	31.00**	-21.94**	6.14	-13.46**	-19.91**	16.67**	14.89**
50	RH 58 x CS 54	4.00	13.04	5.62	12.67	-26.36**	-5.00	55.00**	-18.42**	9.89*	1.69	-0.52	0.06
51	RH 58 x RGN 73	17.78	15.22	-9.84	10.00	68.85**	54.50**	13.97	-23.68**	5.63	-2.26	13.21**	11.49*
52	RH 58 x Urvashi	-37.78**	-39.13**	-5.59	-10.00	-56.00**	-50.50**	44.05**	6.14	-0.05	-7.51	6.99	7.62
53	KM 9201 x NDRE 4	-39.39**	-13.04	-8.56	14.00	-37.46**	11.00	-31.61**	-7.02	-27.32**	-29.59**	14.27**	10.79*

54	KM 9201 x CS 54	-28.00**	-21.74*	-4.37	2.00	-58.14**	-46.00**	1.34	-33.63**	-3.94	-6.94	9.97*	10.61*
55	KM 9201 x RGN 73	14.29**	4.35	-0.55	21.33*	57.38**	44.00**	36.68**	-8.48	-5.15	-8.11*	-9.98**	-12.19*
56	KM 9201 x Urvashi	-2.33	-8.70	12.24	10.00	-15.56	-5.00	-5.56	-30.41**	-4.57	-7.55	-20.16**	-19.70**
57	PRB 2004-3 x NDRE 4	-12.12	26.09**	-22.46**	-3.33	-30.99**	22.50*	-41.29**	-20.18**	12.31**	-5.77	-12.64*	-15.30**
58	PRB 2004-3 x CS 54	-28.92**	-14.49	-13.77	-4.00	-40.70**	-23.50*	0.72	-18.13**	7.60	-9.72*	-1.05	-0.47
59	PRB 2004-3 x RGN 73	-18.67*	-2.17	-16.39	2.00	17.49	7.50	-14.39	-30.41**	11.96**	2.73	-5.59	-7.91
60	PRB 2004-3 x Urvashi	-13.25	4.35	-2.99	8.00	-10.67	0.50	24.10**	0.88	20.84**	1.39	6.29	6.92
	Mean	8.97	1.44	5.96	10.87	11.68	8.64	16.03	9.05	1.44	11.10	0.73	1.02
	C.D at 5%	0.81		1.04		1.35		1.51		5.99		5.48	

S. No.	Crosses	No. of siliquae on main raceme				No. of seeds per siliqua				1000-seed weight (g)			
		E1		E2		E1		E2		E1		E2	
		BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
1	NPJ 141 x NDRE 4	-0.68	-18.36**	-7.16	-13.78*	-3.68	-4.61	5.22	11.90*	4.40	-28.91**	16.68**	-2.39
2	NPJ 141 x CS 54	-27.1**	-34.97**	-3.93	-10.78	4.27	-5.10	8.96	15.87**	-5.35**	-4.90*	40.30**	23.32**
3	NPJ 141 x RGN 73	-13.43**	-17.80**	-14.92*	-20.99**	3.10	-3.16	8.96	15.87**	5.14**	-4.01*	15.23**	1.59
4	NPJ 141 x Urvashi	4.67	-10.44**	27.14**	18.07**	12.31**	6.31	12.94*	20.11**	-9.47**	-5.10**	19.72**	-2.92
5	RH0737 x NDRE 4	3.95	-28.10**	19.37*	-7.62	-8.82	-9.71*	-4.51	0.79	-24.08**	-15.92**	0.00	-1.94
6	RH0737 x CS 54	-9.82*	-19.55**	-10.69	-17.42**	-11.28*	-14.08**	7.02	12.96*	0.68	11.50**	18.56**	16.25**
7	RH0737 x RGN 73	-11.88	-16.33**	16.21*	-0.08	-12.03**	-14.81**	5.26	11.11	3.50*	14.63**	15.77**	13.52**
8	RH0737 x Urvashi	-17.69**	-29.57**	18.12*	-8.59	13.53**	9.95*	0.75	6.35	-16.83**	-7.89**	-0.36	-2.30
9	KMR 10-2 x NDRE 4	-9.37	-26.84**	-13.01*	-10.05	-6.37	-7.28	6.02	11.90*	-19.22**	-19.93**	9.50*	-8.39*
10	KMR 10-2 x CS 54	-11.78**	-21.30**	-4.08	-0.81	3.83	-7.77	-0.75	4.76	-17.26**	-16.87**	4.12	-8.48*
11	KMR 10-2 x RGN 73	-12.99**	-17.38**	-17.01**	-14.18*	-3.10	-8.98*	12.03*	18.25**	-5.08**	-5.92**	12.32**	-0.97
12	KMR 10-2 x Urvashi	-7.37	-20.74**	-22.41**	-19.77**	1.54	-3.88	1.50	7.14	-16.87**	-12.86**	17.63**	-1.59
13	Parashmani 33 x NDRE 4	-9.66*	-27.26**	31.07**	-1.54	-4.41	-5.34	0.72	11.11	-7.33**	-19.18**	-1.27	-17.40**
14	Parashmani 33 x CS 54	4.63	-6.66	18.58**	9.64	-13.57**	-16.50**	-2.88	7.14	10.97**	11.50**	35.58**	19.17**
15	Parashmani 33 x RGN 73	-15.20**	-19.48**	-1.04	-14.91*	10.05*	6.31	13.67*	25.40**	5.14*	-4.01*	-1.90	-13.52**
16	Parashmani 33 x Urvashi	-18.92**	-30.62**	37.82**	-2.84	-1.76	-5.10	-2.40	7.67	-5.13**	-0.54	16.12**	-5.83

17	KMR 10-1 x NDRE 4	2.28	-18.22**	7.50	-5.92	6.62	5.58	-1.97	18.25**	-15.41**	-26.05**	16.58**	-2.47
18	KMR 10-1 x CS 54	-2.91	-13.38**	9.64	1.38	-4.86	-14.56**	-11.18*	7.14	-2.71	-2.24	18.69**	4.33
19	KMR 10-1 x RGN 73	-14.54**	-18.85**	7.78	-5.67	6.20	-0.24	-7.68	11.38	-12.74**	-20.34**	-5.31	-16.52**
20	KMR 10-1 x Urvashi	-7.62	-20.95**	18.89**	4.05	-7.69	-12.62**	-10.31*	8.20	-1.10	3.67	22.98**	-0.27
21	RRN 702 x NDRE 4	3.65	-18.43**	10.68	-16.86**	-13.24**	-14.08**	18.28**	19.84**	-0.26	-23.06**	-11.49**	2.74
22	RRN 702 x CS 54	-6.83	-16.89**	-5.08	-12.24*	-4.56	-8.50	11.23	12.70*	-15.03**	-14.63**	-4.95	10.34**
23	RRN 702 x RGN 73	-29.74**	-33.29**	8.67	-6.56	-8.10	-11.89**	9.11	10.85	-21.39**	-28.23**	-16.36**	-2.92
24	RRN 702 x Urvashi	3.69	-11.28**	9.80	-20.10**	-5.06	-8.98*	4.96	6.35	-1.95	2.79	-26.94**	-15.19**
25	ACN 83 x NDRE 4	8.24	-21.72**	8.67	-8.59	-13.97**	-14.81**	5.34	9.52*	-23.26**	-34.01**	15.60**	2.12
26	ACN 83 x CS 54	-2.59	-13.10**	-10.60	-17.34**	-1.28	-6.55	5.34	9.52	-30.26**	-29.93**	3.70	-8.39*
27	ACN 83 x RGN 73	-17.12**	-21.30**	43.83**	23.66**	-9.23	-14.08**	9.92	14.29*	-10.36**	-18.16**	13.10**	-0.09
28	ACN 83 x Urvashi	-0.49	-14.86**	-10.98	-25.12**	-20.26**	-24.51**	-1.53	2.38	-27.58**	-24.08**	10.10**	-2.74
29	NDR 8501 x NDRE 4	-11.70**	-11.70**	-11.51	-11.51	-19.90**	-19.90**	11.90*	11.90*	-24.22**	-24.22**	-6.71*	-6.71*
30	NDR 8501 x CS 54	-7.50	-7.50	-7.86	-7.86	3.40	3.40	3.69	3.97	-6.77**	-6.33**	27.47**	27.47**
31	NDR 8501 x RGN 73	-24.74**	-24.74	-11.51	-11.51	-5.10	-5.10	-5.21	-3.70	1.84	1.84	20.49**	20.49**
32	NDR 8501 x Urvashi	-23.69**	-23.69**	0.32	0.32	-17.72**	-17.72**	6.61	6.61	5.71**	10.82**	0.27	0.27
33	Kargil Selection x NDRE 4	18.42**	-15.77**	1.14	-6.16	-5.88	-6.80	12.50*	21.43**	-11.87**	-17.14**	14.51	17.84**
34	Kargil Selection x CS 54	4.01	-7.22	-0.09	-7.29	14.21**	1.46	-1.47	6.35	-3.93*	-3.47	19.74	23.23**
35	Kargil Selection x RGN 73	-7.82	-12.47**	1.40	-5.92	24.81**	17.23**	9.56	18.25**	-15.34**	-20.41**	-4.46	-1.68
36	Kargil Selection x Urvashi	6.47	-8.90*	0.35	-6.89	-3.85	-8.98*	8.09	16.67**	-19.60**	-15.71**	-24.03	-21.82**
37	Basanti x NDRE 4	30.31**	-14.44**	-24.69**	-11.51	-0.25	-1.21	-3.86	11.90*	-18.83**	-26.12**	-30.90	-33.22**
38	Basanti x CS 54	-8.56*	-18.43**	-14.97**	-0.08	18.30**	14.56**	7.73	25.40**	-16.66**	-16.26**	-5.21	-8.39*
39	Basanti x RGN 73	-17.34**	-21.51**	-5.66	10.86	7.52	4.13	5.68	23.02**	-19.97**	-26.94**	-16.64	-19.43**
40	Basanti x Urvashi	17.53**	0.56	-32.62**	-20.83**	2.26	-0.97	3.64	20.63**	-20.77**	-16.94**	-16.91	-19.70**
41	Narendra Swarna Rai 8 x NDRE 4	-18.94**	-30.13**	7.85	-6.48	-9.56*	-10.44*	-6.58	12.70*	-40.22**	-32.45**	-35.39	-24.03**
42	Narendra Swarna Rai 8 x CS 54	-4.01	-14.37**	1.75	-5.92	15.03**	2.18	-8.11	10.85	-13.67**	-2.45	2.55	20.58**
43	Narendra Swarna Rai 8 x RGN 73	-7.75	-12.40**	21.96**	5.75	-3.88	-9.71*	-5.70	13.76*	-31.67**	-22.79**	-30.73	-18.55**
44	Narendra Swarna Rai 8	-11.54*	-23.76**	2.62	-11.02	-4.62	-9.71*	-14.91**	2.65	-21.07**	-10.82**	-44.63	-34.89**

	x Urvashi												
45	RMM 09-3 x NDRE 4	0.73	-12.54**	-12.78*	-11.51	-1.47	-2.43	1.48	8.73	-23.12**	-36.67**	-31.01	-27.30**
46	RMM 09-3 x CS 54	-8.88*	-18.71**	-9.50	-8.18	1.54	-3.88	-5.19	1.59	-3.25	-2.79	-6.87	-1.86
47	RMM 09-3 x RGN 73	-12.25**	-16.68**	-7.19	-5.83	0.77	-4.61	1.48	8.73	-19.67**	-26.67**	-28.92	-25.09**
48	RMM 09-3 x Urvashi	-12.19**	-23.76**	-33.71**	-32.74**	3.85	-1.70	14.07	22.22**	-22.71**	-18.98**	-6.87	-1.86
49	RH 58 x NDRE 4	-13.73**	-22.92**	-2.36	-16.21**	-6.98	-2.91	-4.90	-2.38	-34.37**	-34.29**	-33.94	-16.43**
50	RH 58 x CS 54	-9.41*	-19.06**	-12.36	-18.96**	-13.95**	-10.19*	17.53**	20.63**	12.25**	12.79**	1.68	28.62**
51	RH 58 x RGN 73	-5.54	-10.30**	21.02	4.05	-0.93	3.40	9.79	12.70*	-23.98**	-23.88**	-25.00	-5.12
52	RH 58 x Urvashi	-8.00	-17.80**	-2.74	-16.53**	-13.49**	-9.71*	-4.90	-2.38	-11.36**	-7.07**	-34.57	-17.23**
53	KM 9201 x NDRE 4	-6.67	-30.34**	-8.21	-8.51	-3.68	-4.61	5.79	11.11	-15.11**	-9.46**	10.88	-7.24*
54	KM 9201 x CS 54	-13.12**	-22.49**	-14.39*	-14.67*	-5.05	-8.74	4.28	9.52	-1.47	5.10**	32.86	16.78**
55	KM 9201 x RGN 73	-23.84**	-27.68**	-14.39*	-14.67*	-1.52	-5.34	3.53	8.73	11.54**	18.98**	20.94	6.63*
56	KM 9201 x Urvashi	2.21	-12.54**	-38.46**	-38.65**	-4.55	-8.25	5.29	10.58	-21.56**	-16.33**	-54.36	-62.99**
57	PRB 2004-3 x NDRE 4	18.07**	-19.41**	-25.08**	-41.41**	-10.29*	-11.17*	-0.72	9.52	-33.71**	-28.44**	-36.98	-15.11**
58	PRB 2004-3 x CS 54	-15.71**	-24.81**	-9.90	-16.69**	10.93*	-1.46	-6.71	2.91	-14.43**	-7.62**	-8.98	22.61**
59	PRB 2004-3 x RGN 73	-6.57	-11.28**	7.54	-7.54	10.08*	3.40	5.04	15.87**	-19.09**	-12.65**	-20.33	7.33*
60	PRB 2004-3 x Urvashi	4.91	-10.23**	0.73	-21.23**	0.77	-4.61	2.16	12.70*	-4.54*	3.06	-35.54	-13.16**
	Mean	6.56	18.58	1.01	9.50	1.85	5.49	2.93	11.20	12.34	12.28	2.23	3.52
	C.D at 5%	3.61		5.00		1.20		1.45		0.18		0.24	

S. No.	Crosses	Seed yield per plant (g)				Biological yield				Harvest index (%)			
		E1		E2		E1		E2		E1		E2	
		BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
1	NPJ 141 x NDRE 4	-21.65**	-30.54**	-12.42**	-13.52**	-27.51**	-41.33**	-25.03**	-11.77*	-13.38**	18.43**	16.57**	-1.81
2	NPJ 141 x CS 54	-19.51**	-28.65**	-33.12**	-33.96**	-31.40**	-44.48**	-35.95**	-24.62**	9.59**	28.51**	-1.30	-12.23**
3	NPJ 141 x RGN 73	14.04*	5.41	-17.20**	-18.24**	19.27**	-2.58	-15.03**	0.00	-4.46	8.22*	-24.75**	-17.99**
4	NPJ 141 x Urvashi	-21.04**	-30.00**	-9.87**	-11.01*	-21.50**	-36.46**	-6.54	10.00	0.65	10.30*	-16.96**	-19.06**
5	RH0737 x NDRE 4	-34.25**	-41.89**	-27.22**	-20.13**	-20.19**	-45.91**	-20.31**	-13.08*	-21.14**	7.81	-8.63*	-7.98*
6	RH0737 x CS 54	-3.06	-14.32*	-24.07**	-16.67**	22.47**	-17.00**	-5.71	2.85	-20.86**	3.28	-19.47**	-18.90**
7	RH0737 x RGN 73	-14.91*	-21.35**	-44.13**	-38.68**	-30.62**	-43.33**	-33.36**	-27.31**	6.43*	38.89**	-22.51**	-15.54**
8	RH0737 x Urvashi	-1.83	-13.24*	-18.05**	-10.06*	3.05	-16.77**	8.04	17.85**	-22.09**	1.67	-24.15**	-23.61**
9	KMR 10-2 x NDRE 4	-47.72**	-47.30**	41.06**	-8.18	-38.46**	-42.76*/*	54.55**	17.69**	-32.56**	-7.80	-14.29**	-21.89**

10	KMR 10-2 x CS 54	-39.95**	-39.46**	39.61**	-9.12*	-36.37**	-40.81**	40.86**	0.77	-12.67**	2.41	-0.91	-9.70**
11	KMR 10-2 x RGN 73	-28.95**	-28.38**	-1.05	-11.32*	-43.38**	-47.34**	3.74	-14.62**	20.01**	35.94**	-4.49	4.09
12	KMR 10-2 x Urvashi	-28.69**	-28.11**	0.71	-11.01*	-39.08**	-43.33**	22.88**	11.54*	17.30**	27.20**	-18.01**	-20.09**
13	Parashmani 33 x NDRE 4	-11.49	-29.19**	8.53	-11.95**	4.62	-31.31**	47.47**	12.31*	-24.42**	3.32	-25.01**	-21.33**
14	Parashmani 33 x CS 54	5.41	-15.68*	20.54**	-2.20	-4.10	-37.03**	26.80**	-5.38	10.63**	34.87**	-1.33	3.52
15	Parashmani 33 x RGN 73	-2.34	-9.73	12.28*	0.63	-11.00*	-27.30**	50.47**	23.85**	1.85	24.16**	-25.24**	-18.52**
16	Parashmani 33 x Urvashi	-9.21	-22.70**	-25.27**	-33.96**	3.47	-16.43**	-23.73**	-30.77**	-24.39**	-7.83	-7.09*	-2.52
17	KMR 10-1 x NDRE 4	-18.35**	-17.03**	31.32**	7.86	-6.56	-25.01**	21.28**	31.54**	-18.91**	10.87**	4.59	-17.85**
18	KMR 10-1 x CS 54	-12.23*	-10.81	14.09*	-6.29	-0.14	-19.86**	-1.06	7.31	-12.27**	11.23**	-0.84	-11.82**
19	KMR 10-1 x RGN 73	6.38	8.11	-26.32**	-33.96**	25.44**	2.46	-25.53**	-19.23**	-16.63**	5.70	-24.36**	-17.56**
20	KMR 10-1 x Urvashi	-15.43*	-14.05*	-4.63	-15.72**	-9.99	-27.30**	-7.23	0.62	-6.77*	18.21**	-13.97**	-16.16**
21	RRN 702 x NDRE 4	-3.79	-17.57**	-36.71**	-31.13**	2.47	-21.58**	-15.22**	-10.00	-22.91**	5.39	-25.38**	-23.36**
22	RRN 702 x CS 54	-17.98*	-29.73**	-35.26**	-29.56**	-27.08**	-44.19**	-17.39**	-12.31*	7.56*	26.13**	-21.49**	-19.36**
23	RRN 702 x RGN 73	-16.67*	-22.97**	-13.29**	-5.66	-26.42**	-39.90**	12.32*	19.23**	13.65**	28.74**	-27.33**	-20.80**
24	RRN 702 x Urvashi	-8.20	-21.35**	-28.32**	-22.01**	-0.50	-19.63**	-36.96**	-33.08**	-12.48**	-1.98	13.98**	17.06**
25	ACN 83 x NDRE 4	-8.05	-25.95**	9.70	-7.55	-13.12*	-40.47**	40.81**	7.23	-8.66**	24.87**	-22.23**	-13.66**
26	ACN 83 x CS 54	8.72	-12.43*	-2.99	-18.24**	36.17**	-6.70	33.33**	1.54	-20.16**	-6.02	-27.47**	-19.47**
27	ACN 83 x RGN 73	-17.84**	-24.05**	-0.35	-10.69*	-32.03**	-44.48**	42.90**	17.62**	16.26**	36.86**	-31.51**	-23.96**
28	ACN 83 x Urvashi	-17.78*	-30.00**	-29.18**	-37.42**	-29.13**	-42.76**	-12.71*	-20.77**	3.85	22.26**	-28.81**	-20.96**
29	NDR 8501 x NDRE 4	-11.62	-11.62	-48.43**	-48.43**	-29.88**	-29.88**	-41.23**	-41.23**	-7.75*	26.11**	-11.60**	-11.60**
30	NDR 8501 x CS 54	25.14**	25.14**	-20.44**	-20.44**	16.77**	16.77**	-7.00	-7.00	-8.62*	7.15	-14.33**	-14.33**
31	NDR 8501 x RGN	-24.32**	-24.32**	-20.13**	-20.13**	-40.87**	-40.87**	0.00	0.00	12.97**	27.97**	-26.63**	-20.03**

	73												
32	NDR 8501 x Urvashi	-29.46**	-29.46**	-6.60	-6.60	-41.61**	-41.61**	-5.38	-5.38	14.63**	20.95**	-1.15	-1.15
33	Kargil Selection x NDRE 4	6.96	-21.08**	-18.35**	-31.45**	19.03**	-23.01**	15.15*	-12.31*	-24.90**	2.68	-32.74**	-21.71**
34	Kargil Selection x CS 54	36.86**	1.35	-20.60**	-33.33**	49.20**	-3.49	6.91	-22.69**	-10.42**	5.04	-25.74**	-13.56**
35	Kargil Selection x RGN 73	11.11	2.70	38.95**	24.53**	18.78**	-2.98	93.46**	59.23**	-7.16	5.99	-32.64**	-21.59**
36	Kargil Selection x Urvashi	-14.29*	-27.03**	44.48**	27.67**	-9.99	-27.30**	21.69**	10.46*	-12.07**	0.38	-0.60	15.71**
37	Basanti x NDRE 4	22.46**	-5.68	-32.33**	-43.40**	30.08**	-8.41	-40.53**	-40.08**	-24.57**	3.12	13.76**	-5.36
38	Basanti x CS 54	-30.88**	-46.76**	0.38	-16.04**	-17.07**	-41.61**	-5.95	-5.23	-22.22**	-8.79*	-0.23	-11.27**
39	Basanti x RGN 73	-14.91*	-21.35**	-8.42	-17.92**	0.21	-18.15**	4.58	5.38	-15.10**	-3.83	-27.41**	-20.88**
40	Basanti x Urvashi	33.33**	13.51*	12.46*	-0.63	31.82**	6.47	-4.73	-4.00	-2.97	6.36	6.33	3.63
41	Narendra Swarna Rai 8 x NDRE 4	-44.16**	-40.54**	-18.48**	-29.25**	-38.96**	-41.61**	-0.61	-24.31**	-25.56**	1.76	-19.59**	-6.43
42	Narendra Swarna Rai 8 x CS 54	-13.45*	-7.84	20.65**	4.72	-14.00**	-17.74**	29.28**	-3.54	-4.45	12.05**	-6.59*	8.71*
43	Narendra Swarna Rai 8 x RGN 73	2.79	9.46	0.70	-9.75*	-3.05	-7.27	40.19**	15.38**	4.28	18.13**	-32.73**	-21.71**
44	Narendra Swarna Rai 8 x Urvashi	-43.40**	-39.73**	-23.84**	-32.70**	-34.17**	-37.03**	-12.71*	-20.77**	-14.09**	-4.32	-27.09**	-15.15**
45	RMM 09-3 x NDRE 4	5.34	-25.41**	10.53	-33.96**	28.76**	-25.93**	4.14	-20.69**	-26.35**	0.69	6.06	-16.69**
46	RMM 09-3 x CS 54	-29.56**	-47.84**	25.74**	-20.13**	-10.33	-43.33**	39.46**	-0.23	-24.83**	-7.78	-9.88*	-19.86**
47	RMM 09-3 x RGN 73	-12.87	-19.46	2.81	-7.86	-5.40	-22.72**	47.66**	21.54**	-15.01**	4.27	-30.40**	-24.14**
48	RMM 09-3 x Urvashi	16.19*	-1.08**	-12.81*	-22.96**	2.06	-17.57**	11.86*	1.54	-2.13	20.07**	-22.01**	-23.99**
49	RH 58 x NDRE 4	-34.90**	-36.49**	11.57*	-5.97	-19.81**	-42.76**	-7.00	0.15	-18.78**	11.07**	19.67**	-6.00

50	RH 58 x CS 54	19.11**	16.22**	18.66**	0.00	72.49**	23.13**	3.36	11.31*	-30.96**	-5.58	1.15	-10.04**
51	RH 58 x RGN 73	-30.47**	-32.16**	4.91	-5.97	-9.04	-25.70**	-7.86	-0.77	-33.20**	-8.65*	-12.95**	-5.12
52	RH 58 x Urvashi	-26.87**	-28.65**	18.51**	4.72	-26.93**	-40.98**	-9.93*	-3.00	-11.57**	20.93**	11.02**	8.20*
53	KM 9201 x NDRE 4	-29.10**	-32.16**	16.08**	-6.92	-36.66**	-48.48**	19.35**	13.85**	-3.68	31.69**	-2.29	-17.77**
54	KM 9201 x CS 54	-45.48**	-47.84**	18.43**	-5.03	-27.52**	-41.04**	15.81**	10.46*	-24.84**	-11.53**	-3.13	-13.85**
55	KM 9201 x RGN 73	6.78	2.16	23.16**	10.38*	6.66	-12.88**	33.06**	26.92**	-0.32	17.33**	-19.81**	-12.60**
56	KM 9201 x Urvashi	-24.58**	-27.84**	-18.15**	-27.67**	-22.03**	-36.58**	-24.68**	-28.15**	-3.28	13.84**	3.40	0.78
57	PRB 2004-3 x NDRE 4	6.65	25.68**	-3.66	-0.63	5.82	-2.12	-17.78**	-14.62**	-6.06*	28.43**	17.16**	16.58**
58	PRB 2004-3 x CS 54	-33.72**	-21.89**	2.44	5.66	-36.32**	-41.10**	-6.67	-3.08	4.25	32.81**	9.56*	9.02*
59	PRB 2004-3 x RGN 73	-21.10**	-7.03	4.27	7.55	-0.50	-7.96	10.37*	14.62**	-20.41**	1.39	-13.58**	-5.81
60	PRB 2004-3 x Urvashi	-0.69	17.03**	-21.65**	-19.18**	11.39**	3.03	-21.48**	-18.46**	-10.78**	13.66**	-0.05	-0.55
	Mean	11.82	18.38	3.51	14.01	7.71	26.07	5.11	2.09	9.38	11.58	11.46	11.17
	C.D at 5%	1.47		0.96		4.97		4.41		1.73		1.78	

S. No.	Crosses	Oil content (%)			
		E1		E2	
		BP	SV	BP	SV
1	NPJ 141 x NDRE 4	-1.59**	-0.72**	-1.84**	-0.98**
2	NPJ 141 x CS 54	-1.51**	-0.64*	-1.33**	-0.47*
3	NPJ 141 x RGN 73	-3.47**	-2.61**	-3.47**	-2.62**
4	NPJ 141 x Urvashi	-2.36**	-1.50**	-2.28**	-1.42**
5	RH0737 x NDRE 4	2.04**	0.14	1.52**	0.33
6	RH0737 x CS 54	-0.23	-0.77**	0.08	-0.79**
7	RH0737 x RGN 73	0.74**	0.19	2.19**	1.45**
8	RH0737 x Urvashi	1.34**	-0.39	1.46**	-0.48**
9	KMR 10-2 x NDRE 4	0.95**	-0.96**	0.17	-1.00**
10	KMR 10-2 x CS 54	0.76**	0.21	1.25**	0.37*
11	KMR 10-2 x RGN 73	1.66**	1.11**	2.05**	1.31**
12	KMR 10-2 x Urvashi	0.73**	-1.00**	0.68**	-1.24**
13	Parashmani 33 x NDRE 4	2.16**	0.23	1.44**	0.25
14	Parashmani 33 x CS 54	1.91**	1.35**	3.79**	2.89**
15	Parashmani 33 x RGN 73	1.92**	1.37**	2.28**	1.54**
16	Parashmani 33 x Urvashi	1.34**	-0.39	1.46**	-0.47*
17	KMR 10-1 x NDRE 4	-0.83**	-0.61*	-1.46	-1.14**
18	KMR 10-1 x CS 54	0.06	0.27	0.06	0.38*
19	KMR 10-1 x RGN 73	-1.22**	-1.01**	-1.36**	-1.04**
20	KMR 10-1 x Urvashi	1.02	1.24**	0.90**	1.23**
21	RRN 702 x NDRE 4	0.47**	-0.97**	-0.07	-1.24**
22	RRN 702 x CS 54	1.02**	0.47	1.42**	0.53**
23	RRN 702 x RGN 73	-0.11	-0.65**	0.20	-0.53**
24	RRN 702 x Urvashi	2.08**	0.62*	2.34**	0.81**
25	ACN 83 x NDRE 4	-3.82**	-1.42**	-3.87**	-1.21**
26	ACN 83 x CS 54	-1.37**	1.09**	-1.37**	1.35**
27	ACN 83 x RGN 73	-5.22**	-2.85**	-5.54**	-2.93**
28	ACN 83 x Urvashi	-2.77**	-0.34	-2.80**	-0.12
29	NDR 8501 x NDRE 4	-2.49**	-2.49**	1.75**	1.75**
30	NDR 8501 x CS 54	1.76**	1.76**	2.05**	2.05**
31	NDR 8501 x RGN 73	0.65**	0.65**	0.81**	0.81**
32	NDR 8501 x Urvashi	-0.76**	-0.76**	-0.89**	-0.89**
33	Kargil Selection x NDRE 4	0.42	-0.19	-0.47*	-1.46**
34	Kargil Selection x CS 54	0.95**	0.39	1.42**	0.53**
35	Kargil Selection x RGN 73	1.41**	0.87**	1.77**	1.03**
36	Kargil Selection x Urvashi	1.13**	0.51*	1.46**	0.45*
37	Basanti x NDRE 4	-0.60*	0.11	1.04**	1.75**
38	Basanti x CS 54	0.30	1.02**	0.70**	1.40**
39	Basanti x RGN 73	-1.26**	-0.55*	-1.09**	-0.39*
40	Basanti x Urvashi	-1.05**	-0.35	-1.13**	-0.43*
41	Narendra Swarna Rai 8 x NDRE 4	-1.54**	-0.27	-1.82**	-0.65**
42	Narendra Swarna Rai 8 x CS 54	-3.05**	-1.80**	-5.75**	-4.62**

43	Narendra Swarna Rai 8 x RGN 73	-3.06**	-1.82**	-2.89**	-1.73**
44	Narendra Swarna Rai 8 x Urvashi	-3.68**	-2.44**	-3.90**	-2.75**
45	RMM 09-3 x NDRE 4	-2.45**	-1.34**	-2.34**	-1.31**
46	RMM 09-3 x CS 54	-0.47	0.66**	0.10	1.15**
47	RMM 09-3 x RGN 73	-1.40**	-0.28	-1.37**	-0.33*
48	RMM 09-3 x Urvashi	-1.76**	-0.64**	-1.50**	-0.47*
49	RH 58 x NDRE 4	0.30	0.38	0.48**	0.46*
50	RH 58 x CS 54	0.34	0.42	0.56**	0.53**
51	RH 58 x RGN 73	0.09	0.17	0.38**	0.36
52	RH 58 x Urvashi	-0.06	0.02	0.48**	0.46*
53	KM 9201 x NDRE 4	-0.16	-1.25**	-0.35	-1.45**
54	KM 9201 x CS 54	0.95**	0.39	1.43**	0.55**
55	KM 9201 x RGN 73	-0.26	-0.80**	-0.11	-0.84**
56	KM 9201 x Urvashi	-0.71**	-1.79**	-0.08	-1.18**
57	PRB 2004-3 x NDRE 4	1.50**	0.39	1.70**	0.79**
58	PRB 2004-3 x CS 54	0.76**	0.21	1.25**	0.37*
59	PRB 2004-3 x RGN 73	0.19	-0.35	0.47*	-0.26
60	PRB 2004-3 x Urvashi	1.30**	0.18	1.19**	0.28
	Mean	0.28	0.29	0.11	0.15
	C.D at 5%	0.20		0.14	

Obviously, number of siliquae on main raceme, 1000-seed weight, number of seeds per siliqua, harvest index as most important components associated with manifestation of heterosis for seed yield. This confirms the view that heterosis for seed yield is reflected through superiority of yield components. These observations corroborate with the findings of Srivastava *et al.* (1990), Katiyar *et al.* (2000), Yadav *et al.* (2004), Goswami *et al.* (2004) and Singh *et al.* (2007) who also reported that secondary branches per plant, plant height, siliquae on main raceme, primary branches per plant and seeds per siliqua as the important components in determining heterosis for seed yield in Indian mustard. Besides yield, considerable heterosis has been observed for other characters also, but its degree considerably depends upon the characters. Four crosses in E1 and ten crosses in E2 showed heterobeltiosis in desirable direction for number of siliquae on main raceme and seven crosses in E1 and nineteen crosses in E2 for 1000-seed weight. However, four crosses in E1 and ten crosses in E2 for number of siliquae on main raceme and nine crosses in E1 and seven crosses in E2 for number of seeds per siliqua showed standard heterosis in desirable direction over SV (NDR 8501).

The significant better parent heterosis for biological yield in desirable direction was exhibited by all the crosses except RH 58 x CS 54, NDR 8501 x CS 54, NPJ 141 x RGN 73, ACH 83 x CS 54 and KM 9201 x RGN 73 in E1 and Kargil Selection x RGN 73, KMR 10-1 x NDRE 4, RH 0735 x Urvashi, NPJ 141 x Urvashi, KMR 10-2 x NDRE 4 crosses in E2 over SV (NDR 8501) exhibited significant positive heterosis for biological yield.

However, the crosses exhibiting significant better parent heterosis for harvest index in desirable direction were Parasmani 33 X CS 54, RH 0737 x RGN 73, KM 9201 x NDRE 4, RH 58 x Urvashi and RMM 09-3 X Urvashi in E1 and RRN 702 x Urvashi,

Kargil Selection x Urvashi, KMR 10-2 x RGN 73, Narendra Swarna Rai 8 x CS 54 and PRB 2004-3 x NDRE 4 in E2 over SV (NDR 8501) exhibited significant positive heterosis for harvest index.

The significant better parent heterosis for oil content in desirable direction was exhibited by all the crosses except KMR 10-2 x RGN 73, KMR 10-1 x Urvashi, ACH 83 x CS 54, NDR 8501 x CS 54 and NDR 8501 x RGN 73 in E1 and Narendra Swarna Rai 8 x NDRE 4, KMR 10-1 x Urvashi, KMR 10-2 x RGN 73, ACN 83 x CS 54, RH 0735 x RGN 73 in E2 crosses in E2 over SV (NDR 8501) exhibited significant positive heterosis for oil content showed heterosis over SV in desirable direction. Manifestation of considerable heterosis for such yield components have been reported earlier by Ghosh *et al.* (2002), Goswami *et al.* (2004), Shanti Patil *et al.* (2005) and Singh *et al.* (2007).

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