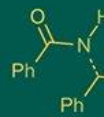


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Combining ability analysis for yield and yield traits in Indian mustard (*Brassica juncea* L. Czern & Coss.)

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Abstract

The present investigation was conducted at S.M.M. Town Post Graduate College during the rabi season to estimate general combining ability (GCA), specific combining ability (SCA) variances and gene effects in Indian mustard, *Brassica juncea*, using Hayman's full diallel analysis. Eight parental genotypes namely Maya, Aashirvaad, Azad-Mahak, Kranti, Basanti, Rohini, Varuna and Urvashi were included in the study. Observations were recorded for days to flower initiation, plant height, number of primary and secondary branches per plant, number of siliques per plant on main raceme, days to maturity, biological yield, number of seeds per silique, test weight, harvest index, oil content and seed yield per plant. Significant variability was observed among the genotypes for all the traits, indicating the presence of sufficient genetic diversity. Both additive and non-additive gene actions played important roles in the inheritance of yield and related traits. Among the parents, Maya, Aashirvaad and Azad-Mahak were identified as good general combiners for seed yield per plant. The crosses Maya × Azad-Mahak, Aashirvaad × Kranti and Basanti × Urvashi exhibited high specific combining ability effects for seed yield per plant. The results suggested that these parents and hybrids could be effectively utilized in mustard improvement programmes for developing high yielding genotypes.

Keywords: Indian mustard, *Brassica juncea*, diallel analysis, combining ability, gene action, GCA, SCA, seed yield, Hayman approach

Introduction

Among the oilseed crops cultivated in India, *Brassica juncea* holds a prominent position because of its economic value and wide adaptability. It is an important member of the rapeseed-mustard group and is extensively grown during the winter season in northern and north-western parts of the country. Globally, rapeseed-mustard ranks after soybean and palm oil crops in terms of edible oil production. Apart from household consumption, vegetable oils are increasingly used in biodiesel industries, thereby enhancing the commercial importance of oilseed crops throughout the world.

The requirement of edible oils is increasing rapidly due to rising population and improved living standards. India depends heavily on edible oil imports to meet domestic demand. Indonesia and Malaysia are the principal exporters of palm oil, while Argentina plays a major role in soybean oil trade. Major biodiesel-producing countries include Brazil, Thailand, the European Union and Malaysia. During the *Rabi* season of 2024-25, rapeseed-mustard in India produced more than 115 lakh tonnes from about 92 lakh hectares. Uttar Pradesh contributes nearly 10-15 percent of total national production. In the state, mustard cultivation is widely practiced under irrigated as well as rainfed conditions. Ballia district recorded productivity of nearly 1430 kg per hectare during 2024-25, indicating its importance in eastern Uttar Pradesh.

Indian mustard seeds contain nearly 38-42 percent oil and the oil cake contains around 24 percent protein. The crop is also considered beneficial from nutritional and medicinal viewpoints because it provides vitamins, minerals and dietary fibre. Nevertheless, conventional mustard varieties contain undesirable substances such as glucosinolates and erucic acid, which reduce the nutritional quality of oil and meal and may lead to health disorders. Consequently, reduction of these antinutritional factors is one of the major aims of modern breeding programmes.

Despite its importance, the average productivity of Indian mustard is still lower than its potential yield because of narrow genetic variability, susceptibility to diseases and pests and

poor adaptability under stress environments. Hence, there is a continuous need to develop improved genotypes possessing high yield, superior oil quality and stable performance across environments. The scientific basis of quantitative genetics established by Ronald A. Fisher, Kenneth Mather and J. L. Jinks has greatly contributed to plant breeding methodologies. Combining ability analysis is widely used to assess the breeding value of parents and to identify promising hybrids for crop improvement. Therefore, the present study was carried out to estimate heterosis and combining ability for seed yield and its contributing traits in Indian mustard.

Materials and Methods

The present investigation was conducted during *Rabi* seasons of 2021-22, 2022-23 and 2023-24 at the Nidharia Agricultural Farm, Shri Murli Manohar Town Post Graduate College. The experimental material comprised eight genetically diverse parents of *Brassica juncea*, namely Maya, Aashirvaad, Azad-Mahak, Kranti, Basanti, Rohini, Varuna and Urvashi. The parental lines were obtained from the Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology. These genotypes differed for important agronomic and yield contributing traits such as flowering duration, maturity, plant height, branching pattern, siliqua formation, seed yield and oil content.

The crossing programme was undertaken following a full diallel mating design including reciprocal crosses according to the method described by Singh and Chaudhary (1985) based on Hayman's diallel approach. The parental genotypes were sown on 17 November 2021 and 24 November 2021 at seven days interval to synchronize flowering for hybridization. All possible crosses among eight parents were attempted to obtain 28 F_1 hybrids and 28 reciprocal crosses. During the subsequent season, parents along with F_1 s and reciprocals were again planted on 23 November 2022 for maintenance of parental lines and advancement of F_2 generations through selfing.

The final experimental material consisting of eight parents, 56 F_1 s including reciprocals and their corresponding 56 F_2 populations was evaluated during *Rabi* 2023-24 in a Randomized Block Design with three replications. Each entry was sown in two rows of four metre length following recommended agronomic practices. Observations were recorded on five randomly selected competitive plants from each replication for twelve quantitative traits viz., days to flowering, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of siliques per plant on main raceme, days to maturity, biological yield per plant (g), number of seeds per siliqua,

test weight (g), harvest index (%), oil content (%) and seed yield per plant (g).

The mean data recorded for all characters were subjected to statistical analysis. Analysis of variance was carried out to test the significance of differences among treatments. Combining ability analysis was performed according to Griffing's (1956) method to estimate general combining ability (GCA), specific combining ability (SCA) and reciprocal effects. The statistical model used was:

$$X_{ijkl} = \mu + g_i + g_j + s_{ij} + r_{ij} + e_{ijkl}$$

where, X_{ijkl} represents the observation of the $i \times j^{th}$ genotype, μ is the population mean, g_i and g_j denote general combining ability effects of parents, s_{ij} represents specific combining ability effect, r_{ij} indicates reciprocal effect and e_{ijkl} denotes environmental error effect.

Graphical analysis based on variance (V_r) and covariance (W_r) values was carried out according to the procedures suggested by Jinks and Hayman (1953) [3], Jinks (1954, 1956) [4, 5] and Hayman (1954, 1957, 1958) [6, 7, 8]. Components of variance due to additive and non-additive gene effects were estimated from mean squares. The ratio of GCA to SCA variances was used to determine the relative importance of additive and non-additive gene action for different characters. Economic heterosis and inbreeding depression were also estimated for yield and its contributing traits.

Results and Discussion

The present investigation conducted in *Brassica juncea* revealed significant variability among parents, F_1 s and F_2 populations for all the traits studied, indicating ample scope for selection and hybrid improvement. Analysis of variance showed highly significant differences among genotypes, while non-significant replication effects confirmed the reliability of the experiment. The variation among hybrids indicated the involvement of both additive and non-additive gene action in the inheritance of yield and related traits.

The estimates of GCA and SCA variances indicated predominance of additive gene effects for most characters, whereas traits like days to flowering, primary branches and test weight showed greater non-additive effects. Kranti and Urvashi were identified as good general combiners for earliness, while Maya, Aashirvaad and Azad-Mahak exhibited desirable GCA effects for seed yield per plant. Urvashi, Rohini and Varuna were superior for siliques per plant and Aashirvaad, Basanti, Varuna and Kranti showed favourable GCA effects for oil content.

Table 1a: Combined analysis of variance for parent and hybrids (F_1 s)

Sourced of variation	df	Days to 50% flowering	Plant height (cm)	No of primary branches	No of secondary branches	No of siliquae/plant on main raceme	Days to maturity	Biological yield per plant (g)	No of seeds per siliqua	Test weight (gm)	Harvest index (%)	Oil content (%)	Seed yield per plant (gm)
REP	2	3.66	63.12	3.92	6.92	29.36	4.57	6.01	1.65	0.002	8.68	5.05	1.75
Treatment	63	24.21**	149.98**	3.67**	16.42**	197.36**	16.17**	674.19**	9.33**	1.225**	50.73**	4.98**	38.66**
PAR	7	11.61**	70.51**	3.75**	19.28**	226.53**	11.98**	385.40**	14.35**	1.02**	44.02**	2.73**	9.89**
F_1	55	25.88**	155.38**	3.73**	15.32**	133.81**	15.09**	688.77**	8.84**	1.27**	51.42**	5.23**	38.79**
PVF1	1	20.25**	409.22**	0.03	57.46**	3488.18**	105.18**	1893.90**	1.29	0.20	59.47**	6.85**	232.58**
EROR	126	1.09	4.97	0.21	0.40	2.88	1.28	2.30	0.42	0.11	0.96	0.04	0.46
Total	191	8.90	53.40	1.39	5.75	67.31	6.23	223.95	3.37	0.480	17.46	1.72	13.07

*, ** significant at 5% and 1% level, respectively

Table 2: Analysis of variance (F₂₅)

Sourced of variation	df	Days to 50% flowering	Plant height (cm)	No of primary branches	No of secondary branches	No of siliquae/plant on main raceme	Days to maturity	Biological yield per plant (g)	No of seeds per siliqua	Test weight (gm)	Harvest index (%)	Oil content (%)	Seed yield per plant (gm)
Replication	2	1.90	5.96	3.22	4.66	13.77	0.64	3.56	5.11	0.34	11.37	0.83	3.91
Treatment	55	31.64**	337.21**	12.19**	27.02**	217.25**	23.22**	428.20**	7.56**	1.46**	142.08**	4.80**	36.51**
Error	110	1.60	4.49	0.33	0.73	1.74	0.92	2.47	0.64	0.09	1.67	0.08	0.50
Total	167	11.66	114.69	4.27	9.43	72.86	8.26	142.69	2.97	0.54	48.03	1.64	12.40

*, ** significant at 5% and 1% level, respectively

Table 3: Mean performance of parents F₁ hybrids and reciprocals

S.N	Parent/Hybrids	Days to 50% flowering	Plant height (cm)	No of primary branches	No of secondary branches	No of siliquae/plant on main raceme	Days to maturity	Biological yield per plant (g)	No of seeds per siliqua	Test weight (gm)	Harvest index (%)	Oil content (%)	Seed yield per plant (gm)
	Parents												
P1	Maya	72.00	190.91	4.67	10.33	70.17	129.33	60.93	14.60	4.38	33.04	38.14	20.13
P2	Aashirvaad	73.33	196.97	4.67	9.07	76.40	130.67	71.67	10.99	3.99	28.18	39.06	20.18
P3	Azad-Mahak	69.00	197.63	5.40	10.67	69.67	132.33	72.21	12.75	3.83	28.36	37.36	20.47
p4	Kranti	71.33	194.69	5.87	11.27	67.13	126.00	69.02	12.57	5.00	25.01	40.67	17.27
p5	Basanti	69.67	194.27	4.27	9.33	69.87	124.67	69.20	10.72	4.96	17.97	38.49	12.44
p6	Rohini	68.00	191.60	4.53	10.80	77.80	126.33	78.03	14.01	4.77	23.21	36.95	18.11
p7	Varuna	71.67	205.05	5.53	11.33	82.07	130.00	77.67	17.48	4.63	23.63	39.96	18.32
p8	Urvashi	66.33	190.00	4.53	11.13	77.60	130.00	70.13	12.72	4.53	25.36	38.38	17.76
	Mean	70.17	195.14	4.93	10.49	73.84	128.67	71.11	13.23	4.51	25.60	38.63	18.09
	Min	66.33	190.00	4.27	9.07	67.13	124.67	60.93	10.72	3.83	17.97	36.95	12.44
	Max	73.33	205.05	5.87	11.33	82.07	132.33	78.03	17.48	5.00	33.04	40.67	20.47
	F1 Hybrids (Direct)												
p1p2	Maya X Aashirvaad	71.00	186.13	6.73	15.60	45.80	125.33	72.67	12.71	5.36	24.19	39.45	17.58
p1p3	Maya X Azad-Mahak	70.67	196.09	4.73	10.87	61.93	124.67	78.27	9.90	5.13	24.13	38.29	18.88
p1p4	Maya X Kranti	69.00	199.33	4.67	10.85	59.47	124.33	62.75	14.16	4.34	24.51	38.74	15.39
p1p5	Maya X Basanti	69.33	197.05	6.67	13.98	71.07	124.33	97.24	8.19	6.02	20.60	37.33	20.03
p1p6	Maya X Rohini	72.00	200.57	7.47	16.97	71.13	123.00	81.17	13.09	5.31	23.44	36.70	19.02
p1p7	Maya X Varuna	73.67	195.37	5.27	10.65	66.44	127.00	73.54	11.09	4.59	21.57	36.87	15.86
p1p8	Maya X Urvashi	74.67	199.07	6.40	12.47	69.40	126.67	76.30	12.77	5.36	22.22	37.41	16.96
p2p3	Aashirvaad X Azad-Mahak	68.67	201.42	7.07	14.20	70.89	125.00	96.51	12.25	4.90	21.08	40.27	20.34
p2p4	Aashirvaad X Kranti	71.00	202.89	6.80	14.73	82.29	126.33	93.03	10.28	5.24	20.12	38.76	18.72
p2p5	Aashirvaad X Basanti	71.67	185.21	7.40	15.93	76.97	129.33	83.53	12.39	4.65	23.59	41.38	19.70
p2p6	Aashirvaad X Rohini	72.33	187.22	6.60	14.27	84.00	126.00	104.50	13.32	5.52	16.57	40.48	17.30
p2p7	Aashirvaad X Varuna	71.00	197.37	6.40	13.33	77.13	128.67	78.69	10.99	6.23	19.92	38.99	15.87
p2p8	Aashirvaad X Urvashi	77.00	189.79	6.53	14.40	84.72	130.33	69.53	12.08	5.02	23.49	38.38	16.34
p3p4	Azad-Mahak X Kranti	71.67	201.76	5.73	12.60	86.46	123.67	75.40	12.64	5.11	20.72	37.19	15.61
p3p5	Azad-Mahak X Basanti	73.33	197.19	5.40	11.60	82.86	126.00	60.00	13.68	5.51	12.53	36.92	7.53
p3p6	Azad-Mahak X Rohini	75.00	198.60	4.80	9.73	78.80	125.33	46.10	12.32	5.25	24.21	39.51	11.16
p3p7	Azad-Mahak X Varuna	73.00	204.80	4.67	10.17	87.17	126.33	42.61	14.19	5.25	23.09	37.49	9.84
p3p8	Azad-Mahak X Urvashi	72.33	205.36	5.67	12.98	81.13	127.33	57.64	12.92	5.30	22.94	38.55	13.23
p4p5	Kranti X Basanti	69.67	204.36	5.47	10.45	80.20	126.67	49.50	12.89	5.86	23.15	37.23	11.46
p4p6	Kranti X Rohini	68.33	214.87	4.80	9.87	66.53	125.33	53.47	10.44	6.29	20.74	36.84	11.09
p4p7	Kranti X Varuna	69.00	193.29	6.13	9.80	65.80	125.33	45.49	11.75	4.93	26.62	37.46	12.11
p4p8	Kranti X Urvashi	68.67	185.43	4.60	9.27	74.06	126.67	51.85	12.59	5.25	22.31	38.20	11.57
p5p6	Basanti X Rohini	72.33	200.10	6.13	12.03	78.97	127.67	78.85	12.67	5.25	23.77	38.28	18.72
p5p7	Basanti X Varuna	77.33	192.84	5.93	14.05	88.07	129.00	96.46	13.19	4.75	18.80	41.65	18.12
p5p8	Basanti X Urvashi	72.33	195.56	6.20	13.73	77.38	128.33	77.52	11.89	4.93	24.44	35.76	18.95
p6p7	Rohini X Varuna	72.33	197.90	6.80	16.48	81.40	130.67	81.83	14.21	5.77	24.33	38.90	19.90
p6p8	Rohini X Urvashi	72.67	206.21	7.07	16.12	87.80	130.33	86.87	13.57	4.72	16.63	38.36	14.44
p7p8	Varuna X Urvashi	69.67	204.90	4.80	9.85	84.47	128.00	65.49	11.57	5.58	21.69	37.26	14.20
	Mean	71.77	197.88	5.96	12.75	75.80	126.70	72.74	12.28	5.27	21.84	38.31	15.71
	Min	68.33	185.21	4.60	9.27	45.80	123.00	42.61	8.19	4.34	12.53	35.76	7.53
	Max	77.33	214.87	7.47	16.97	88.07	130.67	104.50	14.21	6.29	26.62	41.65	20.34
	F1 REciprocal												
p2p1	Aashirvaad X Maya	75.33	211.99	4.80	9.67	68.80	129.33	46.91	11.53	3.92	33.51	38.99	15.71
p3p1	Azad-Mahak X Maya	66.33	192.36	5.67	9.40	76.07	131.00	65.56	15.27	4.89	31.96	36.71	20.94
p3p2	Azad-Mahak X Aashirvaad	68.67	189.76	7.73	12.00	71.27	125.33	63.96	14.19	3.46	24.65	37.74	15.77
p4p1	Kranti X Maya	67.00	218.33	4.87	8.07	79.67	130.00	55.57	12.78	4.88	23.31	37.03	12.95
p4p2	Kranti X Aashirvaad	70.00	207.97	5.20	9.27	78.42	129.33	57.41	12.16	5.72	23.57	38.62	13.53
p4p3	Kranti X Azad-Mahak	76.67	197.74	5.67	9.89	66.47	124.67	50.94	11.12	4.64	20.16	37.97	10.27
p5p1	Basanti X Maya	73.33	204.80	9.73	8.40	79.27	129.33	57.93	10.64	5.49	22.13	39.89	12.83
p5p2	Basanti X Aashirvaad	74.33	198.73	5.73	8.60	68.00	126.33	52.62	11.48	6.01	19.78	38.12	10.41
p5p3	Basanti X Azad-Mahak	70.67	204.31	5.07	8.73	73.46	126.67	56.58	11.12	5.00	23.80	38.89	13.47

p5p4	Basanti X Kranti	68.00	204.03	4.93	6.13	75.62	125.33	50.64	11.96	3.69	22.84	40.47	11.56
p6p1	Rohini X Maya	70.67	194.64	6.00	9.88	78.80	130.33	50.97	12.81	5.89	20.78	39.59	10.58
p6p2	Rohini X Aashirvaad	68.33	198.33	6.00	10.33	76.73	126.33	52.56	13.55	4.67	23.72	38.20	12.46
p6p3	Rohini X Azad-Mahak	70.00	204.40	5.27	9.20	75.53	126.67	57.62	19.31	5.63	19.52	37.06	11.24
p6p4	Rohini X Kranti	67.67	198.35	5.27	8.33	77.63	126.33	58.92	11.47	5.27	20.36	37.69	11.99
p6p5	Rohini X Basanti	71.67	196.63	5.87	8.80	83.80	129.33	64.86	10.39	4.80	19.04	38.91	12.34
p7p1	Varuna X Maya	66.67	210.90	5.80	11.89	77.97	132.33	74.61	11.63	3.91	22.36	38.15	16.69
p7p2	Varuna X Aashirvaad	66.67	208.98	8.93	10.94	82.23	125.67	41.71	11.40	4.10	22.52	37.56	9.38
p7p3	Varuna X Azad-Mahak	67.33	198.49	8.63	13.67	57.87	126.00	52.98	10.87	4.92	31.34	37.46	16.60
p7p4	Varuna X Kranti	67.67	210.83	5.80	10.53	75.30	126.33	45.13	9.44	4.22	25.29	41.53	11.18
p7p5	Varuna X Basanti	73.67	208.14	5.87	10.40	66.47	131.00	46.37	10.16	4.60	23.11	38.53	10.71
p7p6	Varuna X Rohini	75.33	194.83	6.00	11.50	86.60	131.67	78.66	11.55	4.79	14.58	38.35	11.47
p8p1	Urvashi X Maya	71.33	201.04	4.93	10.53	88.45	131.00	61.46	12.80	4.98	29.26	36.82	17.98
p8p2	Urvashi X Aashirvaad	69.00	203.19	6.73	10.91	82.93	129.00	60.25	11.24	6.11	24.06	39.02	14.49
p8p3	Urvashi X Azad-Mahak	67.67	194.36	6.20	14.53	84.68	127.00	79.23	11.91	3.86	22.66	38.11	17.95
p8p4	Urvashi X Kranti	67.33	208.86	5.73	10.23	74.55	128.33	82.70	9.71	4.77	23.41	37.25	19.35
p8p5	Urvashi X Basanti	67.67	200.12	6.27	10.00	75.49	125.67	72.03	10.71	5.16	22.81	39.16	16.43
p8p6	Urvashi X Rohini	66.67	198.36	4.27	9.93	71.80	126.00	64.52	13.39	4.35	12.09	39.49	7.80
p8p7	Urvashi X Varuna	67.00	200.90	5.53	8.40	78.07	129.33	82.74	11.80	5.23	16.55	36.42	13.69
	Mean	69.74	202.19	6.02	10.01	76.14	128.06	60.19	12.01	4.82	22.83	38.35	13.56
	Min	66.33	189.76	4.27	6.13	57.87	124.67	41.71	9.44	3.46	12.09	36.42	7.80
	Max	76.67	218.33	9.73	14.53	88.45	132.33	82.74	19.31	6.11	33.51	41.53	20.94
	Mean all	70.73	199.31	5.83	11.30	75.40	127.55	67.44	12.31	4.97	22.76	38.39	15.13
	Min	66.33	185.21	4.27	6.13	45.80	123.00	41.71	8.19	3.46	12.09	35.76	7.53
	Max	77.33	218.33	9.73	16.97	88.45	132.33	104.50	19.31	6.29	33.51	41.65	20.94
	SE(d)±	0.85	1.82	0.38	0.51	1.39	0.92	1.24	0.53	0.28	0.80	0.17	0.55
	C.D. at 5%	1.69	3.60	0.74	1.02	2.75	1.83	2.45	1.05	0.55	1.59	0.34	1.09
	C.V. (%)	1.48	1.12	7.85	5.58	2.24	0.89	2.26	5.28	6.80	4.31	0.54	4.48

Table 4: Mean performance F₂ hybrids and reciprocals

S.N	Parent/Hybrids	Days to 50% flowering	Plant height (cm)	No of primary branches	No of secondary branches	No of siliquae/plant on main raceme	Days to maturity	Biological yield per plant (g)	No of seeds per siliqua	Test weight (gm)	Harvest index (%)	Oil content (%)	Seed yield per plant (gm)
	F1 Hybrids (Direct)												
p1p2	Maya X Aashirvaad	67.33	182.35	7.00	8.73	70.20	129.67	36.26	11.95	5.38	45.12	38.29	16.36
p1p3	Maya X Azad-Mahak	71.67	184.47	5.13	9.67	75.47	132.67	59.93	11.39	3.78	23.20	36.19	13.90
p1p4	Maya X Kranti	70.67	186.54	13.87	10.67	72.27	125.33	60.23	12.27	4.23	31.11	38.56	18.72
p1p5	Maya X Basanti	65.67	192.98	5.20	9.53	69.95	125.67	48.90	11.65	3.64	30.76	37.82	15.04
p1p6	Maya X Rohini	68.33	188.72	6.20	9.73	86.19	130.00	52.67	11.41	4.97	27.54	41.06	14.51
p1p7	Maya X Varuna	70.33	198.98	4.80	9.00	72.75	127.33	52.53	12.28	5.59	27.82	39.88	14.60
p1p8	Maya X Urvashi	73.67	192.81	5.27	10.80	78.49	134.00	67.57	12.80	3.65	31.38	38.90	21.20
p2p3	Aashirvaad X Azad-Mahak	70.00	202.76	7.01	12.43	71.35	124.33	86.34	13.60	4.08	27.25	37.09	23.53
p2p4	Aashirvaad X Kranti	73.67	207.42	5.33	11.87	69.60	131.00	87.12	11.52	3.83	23.97	37.16	20.88
p2p5	Aashirvaad X Basanti	70.00	164.83	6.60	9.47	55.24	124.67	55.98	16.00	3.92	36.71	37.68	20.54
p2p6	Aashirvaad X Rohini	74.00	191.94	5.20	9.33	69.40	129.00	53.67	12.56	4.69	34.18	38.91	18.34
p2p7	Aashirvaad X Varuna	70.00	182.26	5.00	10.73	74.69	126.67	43.44	12.55	5.24	47.05	40.08	20.44
p2p8	Aashirvaad X Urvashi	72.33	189.36	5.47	11.73	71.43	126.00	50.89	16.69	3.75	22.00	41.90	11.18
p3p4	Azad-Mahak X Kranti	68.00	198.85	4.63	8.00	68.87	124.33	62.25	12.60	4.68	34.26	38.13	21.32
p3p5	Azad-Mahak X Basanti	75.33	198.53	6.80	11.73	77.29	129.33	71.52	14.55	4.61	27.87	37.10	19.91
p3p6	Azad-Mahak X Rohini	69.33	189.13	5.90	11.00	74.85	125.67	50.94	10.55	3.63	37.48	37.19	19.09
p3p7	Azad-Mahak X Varuna	77.33	198.95	5.40	11.94	84.21	126.33	74.39	14.07	3.94	29.52	38.85	21.96
p3p8	Azad-Mahak X Urvashi	72.33	198.50	5.67	9.95	79.40	130.33	55.16	12.77	3.90	37.70	37.13	20.79
p4p5	Kranti X Basanti	76.33	197.75	12.73	9.07	66.77	129.33	51.31	10.21	3.25	34.55	38.21	17.73
p4p6	Kranti X Rohini	74.00	187.02	5.60	9.41	64.89	126.67	62.63	11.85	3.92	34.42	40.95	21.56
p4p7	Kranti X Varuna	66.67	193.23	6.07	12.33	69.07	127.00	65.64	13.12	5.12	30.80	38.01	20.21
p4p8	Kranti X Urvashi	76.00	184.64	7.87	13.43	64.28	125.00	49.87	15.47	4.45	36.45	37.96	18.18
p5p6	Basanti X Rohini	75.00	209.86	4.00	9.80	90.84	131.67	61.78	15.87	3.61	33.32	38.08	20.57
p5p7	Basanti X Varuna	75.67	216.49	10.73	20.67	78.60	128.33	77.33	14.60	4.91	27.95	36.14	21.62
p5p8	Basanti X Urvashi	77.33	196.87	6.40	11.33	73.93	131.00	74.40	12.28	3.55	19.77	37.82	14.71
p6p7	Rohini X Varuna	73.33	197.01	5.93	14.80	75.07	135.33	62.92	10.60	4.43	13.69	39.90	8.60
p6p8	Rohini X Urvashi	69.00	214.99	5.95	8.30	79.09	130.00	79.67	14.95	4.78	25.27	38.78	20.12
p7p8	Varuna X Urvashi	76.67	205.18	10.27	14.87	59.00	125.67	64.23	13.50	3.56	36.83	39.58	23.63
	Mean	72.14	194.62	6.64	11.08	72.97	128.30	61.41	12.99	4.25	31.00	38.48	18.54
	Min	65.67	164.83	4.00	8.00	55.24	124.33	36.26	10.21	3.25	13.69	36.14	8.60
	Max	77.33	216.49	13.87	20.67	90.84	135.33	87.12	16.69	5.59	47.05	41.90	23.63
	F1 REciprocal												
p2p1	Aashirvaad X Maya	67.00	214.10	8.47	16.54	96.24	132.67	74.05	14.40	5.06	24.73	39.24	18.31
p3p1	Azad-Mahak X Maha	67.33	209.99	6.07	9.16	94.23	125.00	60.17	10.80	4.90	21.52	37.13	12.95
p3p2	Azad-Mahak X Aashirvaad	69.00	199.46	6.00	11.40	83.31	124.33	50.60	11.60	3.97	31.42	40.16	15.90

p4p1	Kranti X Maya	69.00	196.01	6.80	15.93	73.98	127.00	50.39	10.92	3.65	26.42	39.34	13.30
p4p2	Kranti X Aashirvaad	68.33	204.39	8.27	11.76	82.60	126.33	63.04	10.68	4.73	19.98	38.55	12.59
p4p3	Kranti X Azad-Mahak	68.33	193.71	8.81	10.07	79.60	125.33	55.68	10.85	3.18	24.80	37.32	13.80
p5p1	Basanti X Maya	71.33	194.53	5.77	12.53	91.52	129.67	89.05	9.72	3.92	15.58	37.61	13.87
p5p2	Basanti X Aashirvaad	69.00	200.53	6.00	9.80	70.00	128.33	52.60	11.03	3.49	21.08	38.03	11.07
p5p3	Basanti X Azad-Mahak	72.00	212.39	5.93	11.67	82.13	130.67	43.65	10.82	3.90	33.15	39.76	14.34
p5p4	Basanti X Kranti	67.00	217.09	8.02	11.40	81.50	128.00	56.92	14.79	4.24	21.59	37.81	12.29
p6p1	Rohini X Maya	72.67	208.33	6.13	11.47	57.79	127.00	64.28	12.38	4.85	22.23	39.58	14.29
p6p2	Rohini X Aashirvaad	75.00	205.66	5.80	11.69	63.53	125.00	61.48	13.04	3.97	22.18	37.67	13.63
p6p3	Rohini X Azad-Mahak	68.33	198.46	6.80	10.00	69.91	125.33	61.72	11.41	3.73	24.81	38.12	15.30
p6p4	Rohini X Kranti	67.00	201.60	5.80	9.00	68.30	129.00	62.46	11.15	4.98	33.60	37.63	20.97
p6p5	Rohini X Basanti	71.67	189.13	6.93	13.67	80.60	131.67	94.03	12.95	3.53	18.10	41.29	17.02
p7p1	Varuna X Maya	70.33	202.80	7.80	16.27	71.05	125.00	76.08	12.48	5.35	18.79	37.97	14.29
p7p2	Varuna X Aashirvaad	66.67	198.60	6.07	15.88	66.44	128.00	55.87	12.37	4.37	37.37	38.41	20.87
p7p3	Varuna X Azad-Mahak	68.00	199.91	8.80	11.00	76.44	125.33	75.41	13.74	4.71	25.68	39.05	19.36
p7p4	Varuna X Kranti	67.33	189.67	12.00	18.40	79.27	131.00	58.16	13.20	3.50	27.11	36.70	15.77
p7p5	Varuna X Basanti	76.00	210.75	8.89	11.78	85.06	128.33	65.98	14.59	4.07	25.37	37.25	16.73
p7p6	Varuna X Rohini	75.00	196.57	7.47	9.89	71.62	131.67	66.66	13.03	5.85	23.47	39.13	15.64
p8p1	Urvashi X Maya	72.00	173.99	6.00	12.27	64.80	124.67	60.00	12.37	3.90	24.83	38.61	14.90
p8p2	Urvashi X Aashirvaad	73.00	196.81	7.73	11.53	74.47	124.67	61.40	13.37	3.58	25.74	37.33	15.81
p8p3	Urvashi X Azad-Mahak	71.33	205.60	6.93	18.53	69.33	128.33	53.23	15.04	4.95	26.05	37.96	13.87
p8p4	Urvashi X Kranti	71.00	187.11	5.40	10.27	68.87	124.33	60.68	13.45	3.90	25.78	37.56	15.66
p8p5	Urvashi X Basanti	66.67	196.03	9.20	21.15	73.87	130.67	66.23	12.04	5.30	27.80	37.23	18.40
p8p6	Urvashi X Rohini	73.00	216.76	8.87	15.47	78.13	129.00	81.71	12.34	6.01	19.55	39.88	15.97
p8p7	Urvashi X Varuna	69.00	197.44	5.73	11.62	70.23	127.33	61.66	13.68	4.79	21.92	39.16	13.51
	Mean	70.08	200.62	7.23	12.86	75.89	127.63	63.69	12.44	4.37	24.67	38.41	15.37
	Min	66.67	173.99	5.40	9.00	57.79	124.33	43.65	9.72	3.18	15.58	36.70	11.07
	Max	76.00	217.09	12.00	21.15	96.24	132.67	94.03	15.04	6.01	37.37	41.29	20.97
	Mean all	71.11	197.62	6.94	11.97	74.43	127.96	62.55	12.71	4.31	27.83	38.44	16.96
	Min	65.67	164.83	4.00	8.00	55.24	124.33	36.26	9.72	3.18	13.69	36.14	8.60
	Max	77.33	217.09	13.87	21.15	96.24	135.33	94.03	16.69	6.01	47.05	41.90	23.63
	SE(d)±	1.03	1.73	0.47	0.70	1.08	0.78	1.28	0.65	0.24	1.06	0.23	0.58
	C.D. at 5%	2.05	3.44	0.94	1.38	2.14	1.56	2.55	1.29	0.48	2.09	0.45	1.15
	C.V. (%)	1.78	1.07	8.32	7.12	1.77	0.75	2.51	6.28	6.82	4.64	0.73	4.19

Table 5: Analysis of variance of combining ability-F1

Source of variation		Days to 50% Flowering	Plant Height (cm)	No of Primary Branches	No of Secondary Branches	No of Siliquae/plant on main raceme	Days to maturity	Biological yield Per Plant (g)	No of Seed Per Siliqua	Test Weight (gm)	Harvest Index (%)	Oil Content (%)	Seed Yield Per Plant (g)
gca	7	7.21**	47.21**	1.30**	5.40**	121.80**	9.44**	185.58**	5.26**	0.262**	64.49**	2.50**	25.12**
sca	28	8.64**	30.81**	1.38**	3.66**	39.74**	4.61**	155.21**	2.90**	0.407**	15.89**	1.13**	5.40**
reci	28	7.71**	69.84**	1.05**	7.31**	77.83**	5.15**	293.16**	2.78**	0.446**	18.93**	1.98**	17.69**
Error	126	0.36	1.65	0.07	0.13	0.96	0.43	0.76	0.14	0.038	0.31	0.01	0.15
s g		0.43	2.85	0.08	0.33	7.55	0.56	11.55	0.32	0.014	4.01	0.16	1.56
s s		8.28	29.16	1.31	3.52	38.78	4.18	154.45	2.76	0.369	15.59	1.12	5.25
s g/s s		0.05	0.10	0.06	0.09	0.19	0.13	0.07	0.12	0.038	0.26	0.14	0.30
(ss/s g) ^0.5		1.01	0.98	1.00	0.98	0.95	0.96	0.99	0.97	1.022	0.93	0.96	0.93

*, ** significant at 5% and 1% level, respectively

Table 6: GCA effects for parents-F1

Var	Parent/ Hybrids	Days to 50% flowering	Plant height (cm)	No of primary branches	No of secondary branches	No of siliquae/plant on main raceme	Days to maturity	Biological yield per plant (g)	No of seeds per siliqua	Test weight (gm)	Harvest index (%)	Oil content (%)	Seed yield per plant (gm)
P1	Maya	0.255	-0.081	-0.041	-0.024	-4.7901 **	0.4166 **	0.7213 **	0.131	-0.049	2.4617 **	-0.3500 **	2.0307 **
P2	Aashirvaad	0.6719 **	-1.7412 **	0.5171 **	0.7528 **	-0.5164 *	0.188	3.2461 **	-0.3086 **	-0.046	0.4844 **	0.6387 **	1.3001 **
P3	Azad-Mahak	-0.057	-0.555	-0.039	0.040	-1.0828 **	-0.6458 **	-2.9667 **	0.6681 **	-0.1952 **	2.4135 **	-0.4346 **	0.7136 **
p4	Kranti	-1.0365 **	2.9136 **	-0.3954 **	-1.1074 **	-2.1574 **	-1.2500 **	-6.5260 **	-0.4978 **	0.036	1.3658 **	0.1541 **	-0.6781 **
p5	Basanti	0.8594 **	-0.8248 **	0.093	-0.5479 **	0.381	-0.3958 **	0.4538 *	-0.8559 **	0.1263 **	-1.6108 **	0.3537 **	-0.8762 **
p6	Rohini	0.026	-1.0368 **	-0.1454 *	0.2992 **	2.7432 **	-0.188	2.6042 **	0.8514 **	0.2148 **	-3.0919 **	-0.0992 **	-1.4599 **
p7	Varuna	0.172	2.4288 **	0.2442 **	0.2534 **	1.7416 **	1.0417 **	-0.8521 **	0.144	-0.0919 *	-0.8950 **	0.1681 **	-1.1391 **
p8	Urvashi	-0.8906 **	-1.1031 **	-0.2325 **	0.3340 **	3.6805 **	0.8333 **	3.3196 **	-0.132	0.005	-1.1277 **	-0.4307 **	0.109
	gca(j)	0.213	0.455	0.094	0.128	0.347	0.231	0.309	0.132	0.069	0.197	0.043	0.136

Table 7: Specific combined ability (sca) for hybrids-F1

Var	Hybrids	Days to 50% Flowering		Plant Height (cm)		No of Primary Branches		No of Secondary Branches		No of Siliquae/plant		Days to maturity	
		SCA	RECI	SCA	RECI	SCA	RECI	SCA	RECI	SCA	RECI	SCA	RECI
p1p2	Maya X Aashirvaad	1.5573 **	-2.1667 **	1.46	-12.9267 **	-0.5671 **	0.9667 **	0.6377 **	2.9667 **	-13.0966 **	-11.5000 **	-0.8125 *	-2.0000 **
p1p3	Maya X Azad-Mahak	-2.3802 **	2.1667 **	-4.5603 **	1.8650 *	-0.5775 **	-0.4667 *	-1.1494 **	0.7333 **	-0.83	-7.0700 **	0.52	-3.1667 **
p1p4	Maya X Kranti	-1.9010 **	1.0000 *	6.5725 **	-9.5033 **	-0.6546 **	-0.10	-0.6788 **	1.3900 **	0.81	-10.1000 **	0.46	-2.8333 **
p1p5	Maya X Basanti	-0.46	-2.0000 **	2.4041 **	-3.8767 **	2.2908 **	-1.5333 **	0.4949 *	2.7900 **	3.8724 **	-4.1000 **	-0.73	-2.5000 **
p1p6	Maya X Rohini	0.37	0.67	-0.70	2.9667 **	1.0621 **	0.7333 **	1.8845 **	3.5467 **	1.3105 *	-3.8333 **	-1.1041 **	-3.6667 **
p1p7	Maya X Varuna	-0.9427 *	3.5000 **	1.36	-7.7633 **	-0.5275 **	-0.27	-0.23	-0.6233 *	-0.45	-5.7667 **	0.67	-2.6667 **
p1p8	Maya X Urvashi	2.9531 **	1.6667 **	1.8125 *	-0.99	0.08	0.7333 **	-0.08	0.9667 **	4.3332 **	-9.5267 **	0.04	-2.1667 **
p2p3	Aashirvaad X Azad-Mahak	-2.6302 **	0.00	-1.54	5.8317 **	1.0642 **	-0.33	1.0406 **	1.1000 **	-3.0272 **	-0.19	-1.9167 **	-0.17
p2p4	Aashirvaad X Kranti	0.18	0.50	4.8325 **	-2.5367 **	0.02	0.8000 **	1.0879 **	2.7333 **	7.3274 **	1.9367 **	1.3542 **	-1.5000 **
p2p5	Aashirvaad X Basanti	0.7865 *	-1.3333 **	-4.8859 **	-6.7600 **	0.10	0.8333 **	0.7949 **	3.6667 **	-3.0847 **	4.4833 **	0.50	1.5000 **
p2p6	Aashirvaad X Rohini	-1.0469 **	2.0000 **	-3.8705 **	-5.5567 **	0.07	0.30	-0.02	1.9667 **	2.4368 **	3.6333 **	-1.3750 **	-0.17
p2p7	Aashirvaad X Varuna	-2.6927 **	2.1667 **	3.0639 **	-5.8033 **	1.0475 **	-1.2667 **	-0.14	1.1967 **	2.7551 **	-2.5500 **	-1.6042 **	1.5000 **
p2p8	Aashirvaad X Urvashi	2.5365 **	4.0000 **	-0.09	-6.6967 **	0.4908 **	-0.10	0.30	1.7467 **	4.9595 **	0.89	1.1042 **	0.67
p3p4	Azad-Mahak X Kranti	4.5781 **	-2.5000 **	-2.0334 *	2.0100 *	0.28	0.03	1.0474 **	1.3533 **	3.9989 **	9.9950 **	-1.4791 **	-0.50
p3p5	Azad-Mahak X Basanti	0.52	1.3333 **	2.7016 **	-3.5600 **	-0.6779 **	0.17	-0.5921 **	1.4333 **	3.1601 **	4.7017 **	-0.17	-0.33
p3p6	Azad-Mahak X Rohini	1.8490 **	2.5000 **	3.6670 **	-2.9000 **	-0.6400 **	-0.23	-2.1392 **	0.27	-0.20	1.6333 **	-0.71	-0.67
p3p7	Azad-Mahak X Varuna	-0.63	2.8333 **	0.35	3.1533 **	0.5871 **	-1.9833 **	0.36	-1.7500 **	-3.8451 **	14.6500 **	-1.7708 **	0.17
p3p8	Azad-Mahak X Urvashi	0.27	2.3333 **	2.0949 **	5.5017 **	0.3471 *	-0.27	2.1160 **	-0.7767 **	4.6076 **	-1.7750 **	-0.56	0.17
p4p5	Kranti X Basanti	-1.6719 **	0.83	2.6794 **	0.17	-0.3550 *	0.27	-1.3215 **	2.1567 **	3.9830 **	2.2900 **	0.10	0.67
p4p6	Kranti X Rohini	-1.6719 **	0.33	5.3081 **	8.2633 **	-0.28	-0.23	-1.3586 **	0.7667 **	-4.2055 **	-5.5500 **	-0.27	-0.50
p4p7	Kranti X Varuna	-1.4844 **	0.67	-2.7042 **	-8.7700 **	0.26	0.17	-0.25	-0.37	-4.7389 **	-4.7517 **	-1.5000 **	-0.50
p4p8	Kranti X Urvashi	-0.7552 *	0.67	-4.0890 **	-11.7133 **	-0.06	-0.5667 **	-0.7451 **	-0.48	-2.9211 **	-0.25	0.38	-0.83
p5p6	Basanti X Rohini	0.43	0.33	0.80	1.74	0.20	0.13	-0.6015 **	1.6167 **	2.5591 **	-2.4133 **	1.5417 **	-0.83
p5p7	Basanti X Varuna	3.7865 **	1.8333 **	-0.54	-7.6500 **	-0.29	0.03	1.2510 **	1.8233 **	-0.56	10.8000 **	1.8125 **	-1.0000 *
p5p8	Basanti X Urvashi	-0.65	2.3333 **	0.34	-2.2833 *	0.5187 **	-0.04	0.8120 **	1.8650 **	-3.3316 **	0.94	-0.9791 *	1.3333 **
p6p7	Rohini X Varuna	2.9531 **	-1.5000 **	-4.4521 **	1.54	0.4433 **	0.4000 *	2.1722 **	2.4917 **	3.8122 **	-2.6000 **	2.7708 **	-0.50
p6p8	Rohini X Urvashi	-0.15	3.0000 **	4.9998 **	3.9283 **	0.19	1.4000 **	1.1266 **	3.0933 **	-2.3268 **	8.0000 **	-0.02	2.1667 **
p7p8	Varuna X Urvashi	-1.6302 **	1.3333 **	2.1491 **	2.0000 *	-0.7029 **	-0.37	-2.7309 **	0.7233 **	0.14	3.1983 **	-0.75	-0.67
	sca(ii)	0.738		1.575		0.325		0.445		1.200		0.801	
	sca(ij)	0.707		1.508		0.311		0.426		1.149		0.767	
	reci(ij)	0.603		1.286		0.266		0.363		0.980		0.654	

Table 8: Specific combined ability (sca) for hybrids-F1

Var	Hybrids	Biological yield Per Plant (g)		No of Seed Per Siliqua		Test Weight (gm)		Harvest Index (%)		Oil Content (%)		Seed Yield Per Plant (g)	
		SCA	RECI	SCA	RECI	SCA	RECI	SCA	RECI	SCA	RECI	SCA	RECI
p1p2	Maya X Aashirvaad	-6.3852 **	7.8800 **	0.02	0.5867 *	-0.2438 *	0.7183 **	1.6358 **	-1.4050 **	0.5657 **	0.2333 **	-0.7900 **	1.4350 **
p1p3	Maya X Azad-Mahak	6.9525 **	6.3550 **	-0.4937 *	-2.6850 **	0.2773 *	0.12	-0.06	-2.0017 **	-0.08	0.7917 **	2.0631 **	0.47
p1p4	Maya X Kranti	-2.2365 **	3.5900 **	1.5571 **	0.6900 **	-0.3542 **	-0.2733 *	0.04	0.30	-0.2864 **	0.8533 **	-0.7869 **	1.2167 **
p1p5	Maya X Basanti	9.2054 **	19.6517 **	-2.1414 **	-1.2267 **	0.7025 **	0.27	-0.9256 **	-1.3850 **	0.2440 **	-1.2800 **	1.4195 **	3.8483 **
p1p6	Maya X Rohini	-4.4600 **	15.0967 **	-0.31	0.14	0.4606 **	-0.2900 *	-0.55	3.1767 **	0.2286 **	-1.4450 **	-0.8734 **	5.7183 **
p1p7	Maya X Varuna	7.0012 **	-0.54	-1.1975 **	-0.27	-0.5844 **	0.3417 *	-2.7048 **	1.6417 **	-0.6737 **	-0.6433 **	0.28	1.0867 **
p1p8	Maya X Urvashi	-2.3638 **	7.4217 **	0.5075 *	-0.01	0.24	0.19	1.2362 **	-1.5467 **	-0.4666 **	0.2950 **	0.23	0.9933 **
p2p3	Aashirvaad X Azad-Mahak	12.7527 **	16.2767 **	0.5807 *	-0.9667 **	-0.5575 **	0.7217 **	-3.6194 **	-0.23	0.4353 **	1.2683 **	0.9354 **	3.7867 **
p2p4	Aashirvaad X Kranti	11.2971 **	17.8117 **	-0.25	-0.9400 **	0.5127 **	-0.24	-0.9200 **	-2.7233 **	-0.4702 **	0.07	1.8970 **	2.5933 **
p2p5	Aashirvaad X Basanti	-2.8294 **	15.4517 **	0.8180 **	0.45	0.2760 *	-0.6800 **	1.8467 **	1.3233 **	0.3936 **	1.6283 **	0.7785 **	4.8933 **
p2p6	Aashirvaad X Rohini	5.4735 **	25.9717 **	0.6107 **	-0.11	-0.05	0.4233 **	-0.9606 **	-2.1417 **	0.4365 **	1.1417 **	-0.06	3.9217 **
p2p7	Aashirvaad X Varuna	-9.3986 **	18.4933 **	-0.9214 **	-0.21	0.3258 **	1.0617 **	-1.4842 **	0.73	-0.8991 **	0.7133 **	-2.6386 **	4.7467 **
p2p8	Aashirvaad X Urvashi	-8.8802 **	4.6433 **	-0.18	0.42	0.6310 **	-0.5433 **	1.4369 **	1.8733 **	0.12	-0.3217 **	-1.0984 **	2.4217 **
p3p4	Azad-Mahak X Kranti	5.4598 **	12.2283 **	-0.5702 *	0.7600 **	0.05	0.24	-1.5542 **	1.3150 **	-0.5035 **	-0.3917 **	0.8002 **	4.1700 **
p3p5	Azad-Mahak X Basanti	-6.4033 **	1.7117 **	0.31	1.2783 **	0.3487 **	0.26	-0.56	-2.8433 **	-0.3781 **	-0.9867 **	-1.6917 **	-1.2233 **
p3p6	Azad-Mahak X Rohini	-14.9804 **	-5.7617 **	2.0140 **	-3.4933 **	0.4452 **	-0.19	3.9085 **	8.8533 **	0.4548 **	1.2233 **	-1.6580 **	2.9600 **
p3p7	Azad-Mahak X Varuna	-15.5908 **	-5.1817 **	-0.5647 *	1.6600 **	0.3952 **	0.17	7.5967 **	2.9117 **	-0.6225 **	0.02	0.04	-0.38
p3p8	Azad-Mahak X Urvashi	0.87	-10.7950 **	-0.40	0.51	-0.20	0.7200 **	1.5777 **	5.3500 **	0.8296 **	0.2200 *	1.1664 **	0.6400 *
p4p5	Kranti X Basanti	-11.0590 **	-0.57	1.5005 **	0.47	-0.3627 **	1.0833 **	3.0919 **	0.21	-0.02	-1.6233 **	-1.0401 **	-0.05
p4p6	Kranti X Rohini	-7.0910 **	-2.7250 **	-1.6802 **	-0.51	0.5521 **	0.5067 **	-0.53	2.5317 **	-1.1522 **	-0.4250 **	-1.6730 **	0.8000 **
p4p7	Kranti X Varuna	-14.5148 **	0.18	-1.3322 **	1.1533 **	-0.3446 **	0.3567 **	2.8510 **	3.6550 **	0.8071 **	-2.0350 **	-1.8921 **	1.7150 **
p4p8	Kranti X Urvashi	3.2769 **	-15.4250 **	-0.5039 *	1.4400 **	-0.01	0.24	-0.11	1.8617 **	-0.3641 **	0.4750 **	0.6764 **	-2.6417 **
p5p6	Basanti X Rohini	1.5942 **	6.9933 **	-0.7487 **	1.1400 **	-0.2962 *	0.23	0.9579 **	2.3617 **	-0.03	-0.3117 **	1.2652 **	3.1900 **
p5p7	Basanti X Varuna	4.6071 **	25.0467 **	0.11	1.5133 **	-0.3329 **	0.08	-1.6823 **	-2.1517 **	1.2025 **	1.5600 **	-0.17	3.7067 **
p5p8	Basanti X Urvashi	3.7971 **	2.7483 **	0.01	0.5933 *	-0.06	-0.12	1.2221 **	0.8133 *	-0.8270 **	-1.6983 **	1.8495 **	1.2600 **
p6p7	Rohini X Varuna	11.2867 **	1.5867 *	-0.39	1.3333 **	0.18	0.4900 **	-1.6996 **	4.8733 **	0.1871 *	0.2750 **	1.6781 **	4.2167 **
p6p8	Rohini X Urvashi	2.5633 **	11.1750 **	0.4769 *	0.09	-0.6596 **	0.19	-5.3752 **	3.4617 **	1.0876 **	-0.5633 **	-3.0984 **	4.3550 **
p7p8	Varuna X Urvashi	4.4429 **	-8.6283 **	-0.6085 **	-0.12	0.5171 **	0.18	-1.2004 **	5.3700 **	-1.2631 **	0.4233 **	0.21	2.0883 **

	sca(ii)	1.071		0.458		0.239		0.681		0.148		0.470	
	sca(ij)	1.025		0.439		0.229		0.652		0.142		0.450	
	reci(ij)	0.874		0.374		0.195		0.556		0.121		0.384	

Specific combining ability analysis identified several promising hybrids for yield and yield contributing traits. Crosses such as Maya × Azad-Mahak, Aashirvaad × Kranti, Azad-Mahak × Urvashi and Maya × Basanti exhibited high positive SCA effects for seed yield per plant, indicating the importance of dominance and epistatic interactions in expression of heterosis. Crosses like Aashirvaad × Kranti and Aashirvaad × Urvashi, Azad-Mahak × Urvashi were superior for siliquae per plant, while Aashirvaad × Azad-Mahak, Aashirvaad × Kranti and Rohini × Varuna performed better for biological yield. Overall, the study indicated that both additive and non-additive gene actions played an important role in inheritance of yield and related traits in Indian mustard.

Conclusion

The present investigation in *Brassica juncea* revealed the presence of considerable genetic variability among parents, F₁s and F₂ populations for all the characters studied, indicating sufficient scope for selection and genetic improvement. Significant differences among genotypes confirmed the existence of wide diversity for yield and its contributing traits.

The estimates of general combining ability (GCA) and specific combining ability (SCA) variances indicated the involvement of both additive and non-additive gene actions in the inheritance of different traits. Additive gene effects predominated for most characters, whereas non-additive gene action was more important for days to flowering, primary branches and test weight. These results suggested that simple selection methods may be effective for traits governed mainly by additive effects, while heterosis breeding could be more useful for traits controlled by dominance and epistatic interactions.

Among the parents, Maya, Aashirvaad and Azad-Mahak were identified as superior general combiners for seed yield per plant, while Urvashi, Rohini and Varuna were found promising for siliquae per plant. Kranti and Urvashi proved useful for earliness and Aashirvaad, Basanti, Varuna and Kranti were desirable combiners for oil content.

Among the hybrids, Maya × Azad-Mahak, Aashirvaad × Kranti, Azad-Mahak × Urvashi and Maya × Basanti exhibited high SCA effects for seed yield per plant and may be exploited for heterosis breeding. Crosses such as Aashirvaad × Kranti, Aashirvaad × Urvashi and Rohini × Varuna also showed superior performance for important yield contributing traits. Overall, the study indicated that both selection and heterosis breeding approaches can be effectively utilized for improvement of yield and related traits in Indian mustard. The superior parents and promising cross combinations identified in the present investigation may be used in future breeding programmes for development of high yielding, early maturing and better oil quality mustard varieties.

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