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Heterosis and combining ability of F_1 and F_2 generations of Indian mustard for seed yield and its attributes

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Abstract

Combining ability analysis on a L X T of F_1 and F_2 generations in Indian mustard revealed that general combining ability effects of the parents had a positive association with their per se performance. The parents EC401574, Pusa Bold and Rajendra Sufalam for seed yield and number of siliqua on main raceme, RAURD 153, RAURD 34 and RAURD 32 for days to flowering and main shoot length, EC 399788 number of siliqua per plant and number of secondary branches per plant, were good general combiners. In most of the crosses, the specific combining ability estimates for most of the traits were higher in the F_1 than in the F_2. EC 401574/Rajendra Sufalam for number of siliqua per plant followed by seed yield per plant and number of secondary braches per plant were identified as potential cross combinations on the basis of better parent heterosis and specific combining ability. It was evident from the two analyses that additive and non-additive gene effects are important for the inheritance of different characters studied. However, the relative magnitude of non-additive was higher than additive component for all the characters in both the populations. The hybrid RAURD 153 x Pusa Bold for number of primary branches per plant, EC 399788 x Pusa Bold for secondary branches per plant, EC 401574/ Rajendra Sufalam for seed yield per plant, number of siliqua per plant and siliqua on main raceme, RAURD 214/ Rajendra Sufalam for siliqua length and RAURD 32/Vardan for seeds per siliqua manifested high sca as well as heterotic effects. Such crosses are expected to throw better segregants for yield and its components in the subsequent generations which can be exploited effectively for mustard improvement.

Key words: *Brassica juncea, combining ability and heterosis.*

Introduction

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is an important oilseed crop of India, occupies a premier position in Indian agriculture. In India, the average productivity of this crop oscillating near to 1.2 tonne for a long time which is much below the world average of about 1.9 tonnes/ha. Therefore, it is highly needed to increase the productivity of Indian mustard in the country to meet the growing demands for edible oil. Comprehensive analysis of the combining ability involved in the inheritance of quantitative characters and in the phenomenon of heterosis is necessary for the evaluation of various possible breeding procedures (Allard, 1960). Improvement of superior varieties could be done by reshuffling the genes through hybridization from proper parents. Moreover, it is also necessary to know about the nature and magnitude of gene action responsible for controlling the inheritance of various yield attributes along with combining ability of the parents and their cross combinations in order to make use of them in further crop improvement program.

The increase in productivity through breeding efforts has not been adequate because of traditional selection method following hybridization. Heterosis breeding could be a potential alternative for achieving quantum jumps in production and productivity. Since, commercial exploitation of heterosis in several crop plants has caused a major breakthrough in yield levels. The magnitude of heterosis particularly for yield is of paramount importance and if the heterosis is practically and economically feasible it can help to reach high yield levels and thereby higher output of yield and oil in mustard. The earliness and higher seed yield with higher yield per cent are the major components to increase the cash value of this crop, so there is an urgent need to develop hybrid varieties which are high yielding, early maturing and well adapted to local semidry agro-climatic conditions. The studies on heterosis, combining ability and nature of gene action are useful in formulating effective breeding strategies and choice of suitable parents for crosses in different breeding programmes. The present investigation has been undertaken to study selection of parents and crosses in a LxT cross of Indian mustard.

Materials and Methods

The experimental material comprising the selected parents (10 lines and 4 testers) are involved in hybridization and generate the 40 F_1s materials during *Rabi* 2011-12. The generated 40 F_1s, F_2s and 14 parents along with one check of Indian mustard were grown in Randomized Block Design with three replications during *Rabi* 2012-13 and 2013-14 respectively, at research farm of Tirhut College of Agriculture, Dholi, Muzaffarpur (Rajendra Agricultural University-Pusa) Bihar, India. Entries were sown in a plot consisting of three rows (F_1s and parents) and five rows (F_2s) of 5m length in three replications with inter and intra row spacing of 30cm x 10cm. recommended package of practices for Indian mustard ware followed to raise a healthy crop. Data were recorded on five randomly selected competitive plants in F_1s and twenty plants in F_2s of each genotype in all the replications for thirteen characters *viz.,* days to 50% flowering, days to maturity, main shoot length (cm), primary branches per plant, secondary branches per plant, number of siliqua per plant, siliqua length (cm), number of seeds per siliqua, number of siliqua on main raceme, siliqua density (siliqua/cm^2), biological yield per plant (g), harvest index (%) and seed yield per plant (g) and their mean values were subjected to various statistical and biometrical analyses. Combining ability analysis was done using line x tester method (Kempthorne, 1957). Heterosis was estimated from mean values according to Fehr (1987) and Significance test for GCA and SCA effects were performed using t-test, Better parent heterosis (Hb) or heterobeltiosis (Fonesca and Patterson, 1968) and standard heterosis (Hc) were determined as outlined by (Meredith and Bridges, 1972).

Results and Discussion

The gca effects for different characters under study in both F_1 and F_2 analyses are presented in Table 1. The perusal of positive and significant gca effects indicated that parents EC 399788 for number of secondary branches per plant and biological yield per plant; Pusa bold and EC 401574 for number of siliqua per plant, number of siliqua on main raceme and seed yield per plant; RAURD 214 for siliqua length, siliqua density and biological yield per plant, Vardan for siliqua length and RAURD 78 for number of siliqua per plant as well as posses negative significant gca effect for days to 50% flowering and days to maturity; whereas negative and significant gca effects exhibited RH-30, RAURD 32, RAURD 34 and RAURD 153 for days to 50% flowering and main shoot length, whereas RAURD 78 and JD-6 exhibited only days to 50% flowering and days to maturity, respectively in both F_1 and F_2 generations. The parents such as EC 401574 and Pusa Bold were found to be good combiner for seed yield/ plant and may yield transgressive segregants in F_2 generation. These parents also showed high *per se* performance. The study of gca effects of parents suggested that there was a positive association between the *per se* performance of the parents and the estimates of their gca effects for days to 50% flowering, main shoot length, secondary branches per plant, number of siliqua per plant, number of siliqua on main raceme and seed yield per plant. The present study resulted similar finding as reported by Kumar *et al.* (2014). High gca effects are mostly due to additive or additive x additive interaction effects. In view of this, breeders may utilize the good general combiners in specific breeding programme for improvement of seed yield in mustard. It appears that the gca rank for grain yield is related to the gca for the useful yield components. It is therefore recommended that the breeder should breed for superior combining ability for the component traits with an ultimate objective to improve the overall gca for seed yield in mustard crop. In order to synthesize a dynamic population with most of the favorable genes are accumulated, it will be pertinent to make use of these parents, which are good general combiner for several characters, in multiple crossing programme. Similar observations were made by Singh and Sachan (2003) and Singh *et al.* (2004).

The heterosis cannot be exploited directly; hybrid vigour is used to identify superior hybrids, as they offer more probability of developing better segregants. Therefore, knowledge on the magnitude and direction of heterosis is important to exploit the phenomenon of hybrid vigor. The top three crosses selected on the basis of sca effects in F_1 and F_2 analyses and their heterotic effects over the better parent (BPH) and standard check variety (SH) are presented character wise in Table 2. Most of these cross combinations were uniformly superior both from sca as well as heterosis point of view. Among the hybrids, RAURD 214/Pusa Bold, RAURD 78/ Pusa Bold in F_1 and EC 399788/JD-6 in F_2 were identified as the most superior combinations as well as highly significant sca effect for seed yield per plant. Best combinations, in general included one good general combiner and one poor or average general combiner for most of the characters studied. The desirable performance of these hybrids over the better parent may be ascribed to the complementary gene effects.

The highest heterobeltiosis (185.35%) were identified as potential cross combinations on the basis of better parent heterosis and specific combining ability for number of siliqua per plant followed by seed yield per plant and number of secondary braches per plant, the crosses namely EC401574/ Rajendra Sufalam, RH-30/vardan & EC

Table 1. General combining ability effects of parents in India mustard for seed yield and component characters

S.N.	Parents	DFF		DM		MSL		PBP		SBP		SPP		SMR	
		F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
1	RH -30	-1.84**	-1.78**	-0.17	-0.02	-9.72**	-19.01**	0.80*	0.131	4.21**	-1.79**	148.87**	-8.740**	-3.87**	-7.91**
2	RAURD-172	-0.43	2.13**	2.83**	1.57**	-8.71**	-2.43*	-0.58	0.314*	-2.39**	0.65	-117.60**	10.95**	-2.75**	5.09**
3	RAURD-32	-2.51**	-2.62**	-3.67**	-0.6	-2.51*	0.58	-0.83*	-0.29*	-2.79**	-0.48	162.00**	-1.57	-4.50**	0.93
4	RAURD-78	-0.84*	-2.45**	-1.08*	-1.35**	-1.11	0.43	0.2	-0.11	0.43	1.07*	31.00**	8.15**	5.32**	1.45
5	RAURD-34	-3.76**	-1.70**	-4.75**	-0.1	-7.09**	-6.02**	-1.40**	-0.21	-6.47**	-0.68	-276.96**	-4.68*	5.72**	0.02
6	RAURD-214	-3.92**	-0.28	1.67**	-0.68	-4.98**	7.81**	0.69*	-0.50**	3.32**	-0.07	45.52**	-33.16**	-1.90**	-3.37**
7	RAURD-153	-4.93**	-2.28**	0.08	-3.18**	-3.61**	-4.30**	0.42	-0.60**	-2.66**	-0.67	-71.69**	-34.85**	-1.80**	-2.54*
8	EC 401574	0.74	1.47**	2.33**	1.73**	2.50*	14.82**	0.15	-0.21	1.58**	-0.38	92.75**	-76.25**	3.95**	3.86**
9	EC 399788	12.16**	3.38**	1.67**	1.73**	18.44**	9.53**	0.65	1.86**	3.59**	2.08**	5.92**	131.52**	-1.95**	3.17**
10	RAURD-170	5.32**	4.13**	1.08*	0.90*	16.78**	6.93**	-0.1	-0.38**	1.18*	0.29	-19.81**	8.63**	1.78**	-0.69
11	Vardan	0.69*	-0.43	0.62	0.3	-0.85	-3.49**	0.11	0.32**	-0.14	1.56**	-58.67**	6.94**	-1.95**	0.80
12	Pusa Bold	1.56**	1.8	0.68*	0.4	10.31**	6.91**	0.67**	-0.04	1.00**	-1.93**	102.76**	6.19**	0.86*	2.09**
13	Rajendra Sufalam	-0.81**	-0.1	-0.08	0.27	-0.4	-3.18**	-0.56**	3.89**	-2.25**	-0.07	-79.75**	-2.56*	2.84**	-2.371**
14	JD-6 (Pusa Mahak)	-1.44**	-1.270**	-1.22**	-0.970**	-9.06**	-0.24	-0.22	-0.201**	1.38**	0.44	35.66**	-10.568**	-1.75**	-0.52

S.N.	Parents	SL		SS		SD		BYP		HI		SYP	
		F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
1	RH -30	0.04	-0.04	-0.60*	-0.87**	0.18**	-0.08**	2.97*	-4.55**	1.01*	-3.69**	1.34**	-3.14**
2	RAURD-172	-0.22**	0.12**	1.02**	-0.21	-0.04	-0.02	-10.98**	-0.8	-0.16	0.62	-2.34**	0.42
3	RAURD-32	0.14	0.33**	0.57*	0.29	0.11**	0.02	-8.25**	9.20**	-1.19**	-1.21	-2.86**	1.86**
4	RAURD-78	0.16*	0.04	-0.36	-0.31	-0.09**	-0.03	0.87	6.12**	0.25	-3.14**	0.85	-0.47
5	RAURD-34	0.07	0.07	-0.28	0.23	0.02	0.02	-19.78**	-10.97**	3.69**	2.72**	-0.69	-0.403
6	RAURD-214	0.37**	0.11**	0.22	0.66**	0.10**	0.05*	21.99**	9.78**	-1.02*	-2.88**	3.43**	-1.31**
7	RAURD-153	0.40**	-0.05	0.47	-0.04	0.04	-0.01	-2.46*	-1.68	0.07	-0.57	-0.8	-0.28
8	EC 401574	-0.59**	-0.31**	-1.16**	0.29	-0.08**	0.02	19.32**	-6.51**	0.28	5.49**	5.38**	2.25**
9	EC 399788	-0.25**	-0.16**	0.45	0.59**	-0.12**	0.05*	5.40**	8.12**	-1.69**	-0.44	-0.87	0.91**
10	RAURD-170	-0.1	-0.12**	-0.35	-0.65**	-0.13**	-0.06**	-9.07**	-8.72**	-1.24**	3.11**	-3.46**	0.16
11	Vardan	0.11*	0.12**	-0.01	0.38**	0.03	0.05**	-7.74**	7.20**	-0.15	-0.71	-2.10**	0.78**
12	Pusa Bold	-0.1	-0.09**	-0.2	-0.08	-0.13**	0.23**	5.69**	-2.07*	-0.04	1.68**	1.19**	0.81**
13	Rajendra Sufalam	-0.02	-0.08*	-0.16	-0.43**	0.03	0.02*	2.48**	-0.8	0.13	-2.52**	0.84**	-1.53**
14	JD-6 (Pusa Mahak)	0.02	0.05	0.38*	0.13	0.08**	0.001	-0.43	-4.33**	0.06	1.55**	0.07	-0.06

Table 2: Top three hybrids selected separately in F_1 and F_2 on the basis of sca effects and heterosis over better parent (BPH) and standard variety (HS)

	Characters	Generations	Crosses	SCA effects	Heterobeltiosis Crosses	Heterobeltiosis (%)	Standard Heterosis Crosses	Standard Heterosis (%)
1	Days	F1	RAURD 153/JD-6	-6.64**	RAURD 153/JD-6	-15.44**	RAURD 153/JD-6	-25.44**
	to 50%		EC 399788/Pusa Bold	-3.39**	RAURD 78/JD-6	-11.18**	RAURD 34/Vardan	-12.43**
	flowering		RAURD170/Vardan	-7.69**	RAURD 172/JD-6	-8.72**	RAURD 78/JD-6	-10.65**
		F2	EC 401574/Vardan	-5.90**	RAURD 78/JD-6	-2.79**	RAURD 32/JD-6	-16.75**
			RAURD 32/JD-6	-2.98**	-	-	EC 401574/Vardan	-13.88**
			RH-30/Rajendra Sufalam	-2.98**	-	-	RAURD 34/JD-6	-12.92**
2	Days to	F1	RAURD 153/JD-6	-5.12**	RAURD 34/Vardan	-6.19**	-	-
	maturity		RAURD 32/Rajendra Sufalam	-2.50*	RAURD 34/Pusa Bold	-5.95**	-	-
			-	-	RAURD 34/Rajendra Sufalam	-5.71**	-	-
		F2	RAURD 172/Vardan	-1.97*	-	-	-	-
			EC 401574/Rajendra Sufalam	-2.10**	-	-	-	-
			RAURD170/Vardan	-2.63**	-	-	-	-
3	Main	F1	EC 399788/Pusa Bold	-18.26**	RAURD 172/JD-6	-23.03**	RAURD 172/JD-6	-19.89**
	Shoot		RAURD 153/JD-6	-17.16**	RAURD 172/Rajendra Sufalam	-17.37**	RAURD 153/JD-6	-19.69**
	length		RAURD 214/Pusa Bold	-12.72**	RAURD 172/Vardan	-10.69**	RAURD 32/JD-6	-14.51**
		F2	RAURD 214/Vardan	-31.47**	RAURD 172/Pusa Bold	-13.06**	RAURD 214/Vardan	-17.55**
			RAURD 78/JD-6	-22.31**	RH-30/Vardan	-7.89**	RAURD 32/JD-6	-16.55**
			EC 399788/Pusa Bold	-20.58**	RAURD 34/Pusa Bold	-6.57**	RAURD 78/JD-6	-15.12**
4	Primary	F1	RAURD 153/Pusa Bold	1.78**	EC 399788/Vardan	67.33**	RAURD 153/Pusa Bold	45.16**
	branches		RAURD 78/Pusa Bold	1.67*	RH-30/Vardan	51.75**	RAURD 78/Pusa Bold	41.13**
	per		RH-30/Vardan	1.49*	EC 401574/Rajendra Sufalam	51.55**	RH-30/Vardan	39.52**
	plant	F2	EC 399788/Vardan	1.33**	EC 399788/Vardan	71.24**	EC 399788/Vardan	61.73**
			RAURD 172/Vardan	0.81**	EC 399788/Pusa Bold	52.70**	EC 399788/Pusa Bold	39.51**
			RH-30/Pusa Bold	0.55**	EC 399788/Rajendra Sufalam	31.13**	RAURD 172/Vardan	23.46**
5	Secondary	F1	EC 399788/Pusa Bold	9.95**	EC 399788/Pusa Bold	86.13**	EC 399788/Pusa Bold	72.24**
	branches		RAURD 214/Rajendra Sufalam	8.68**	EC 399788/Rajendra Sufalam	80.44**	RAURD 170/JD-6	57.01**
	per		RAURD 170/JD-6	8.59**	EC 401574/Rajendra Sufalam	68.00**	RH-30/Pusa Bold	51.34**
	plant	F2	EC 399788/Vardan	10.11**	EC 399788/Vardan	47.98**	EC 399788/Vardan	31.05**
			RAURD 78/Rajendra Sufalam	6.01**	RAURD 78/Rajendra Sufalam	16.09**	-	-
			RAURD 32/JD-6	4.62**	-	-	-	-
6	No. of	F1	RAURD 32/JD-6	642.66**	EC 401574/Rajendra Sufalam	185.35**	EC 401574/Rajendra Sufalam	76.57**
	siliqua		RH-30/Vardan	481.92**	RH-30/Vardan	137.54**	RAURD 32/JD-6	148.82**
	per		EC 401574/Rajendra Sufalam	326.58**	EC 399788/Rajendra Sufalam	125.36**	RH-30/Vardan	110.12**
	plant	F2	RAURD 78/Rajendra Sufalam	149.47**	EC 399788/Vardan	64.86**	EC 399788/Pusa Bold	12.91**
			EC 399788/Pusa Bold	141.44**	EC 399788/Pusa Bold	63.93**	EC 399788/Vardan	5.63**
			RAURD 32/JD-6	104.13**	EC 399788/Rajendra Sufalam	9.74**	-	-
7	No. of	F1	EC 401574/Rajendra Sufalam	12.03**	RAURD 78/Vardan	42.86**	RAURD 78/Vardan	35.29**
	Siliqua on		RAURD 78/Vardan	10.32**	EC 401574/Rajendra Sufalam	32.58**	EC 401574/Rajendra Sufalam	46.62**
	main		RH-30/Rajendra Sufalam	9.58**	EC 399788/Vardan	24.60**	RH-30/Rajendra Sufalam	23.97**
	raceme	F2	RAURD 34/Vardan	9.27**	EC 399788/JD-6	18.57**	RAURD 172/Pusa Bold	15.24**
			RAURD 172/Pusa Bold	8.74**	RAURD 32/Vardan	17.92**	-	-
			RAURD 32/JD-6	7.09**	EC 399788/Vardan	17.62**	-	-

8	Siliqua length	F1	EC 401574/Pusa Bold	0.64**	RAURD 153/Vardan	32.89**	RAURD 153/Vardan	36.01**
			RAURD 214/Rajendra Sufalam	0.61**	RAURD 214/Rajendra Sufalam	30.00**	RAURD 214/Rajendra Sufalam	32.29**
			RAURD 153/Vardan	0.59**	RAURD 34/Vardan	16.25**	RAURD 78/JD-6	22.90**
		F2	EC 401574/Rajendra Sufalam	0.28**	RAURD 32/Vardan	17.29**	RAURD 32/Vardan	20.40**
			RAURD 34/JD-6	0.27**	EC 399788/JD-6	15.35**	RAURD 34/Vardan	13.09**
			RAURD 32/Vardan	0.25**	RAURD 32/JD-6	12.21**	RAURD 172/JD-6	11.17**
9	No. of seeds per siliqua	F1	RAURD 34/Vardan	2.05**	RAURD 172/JD-6	19.66**	RAURD 172/JD-6	33.13**
			RAURD 214/Rajendra Sufalam	1.70**	RAURD 32/Vardan	18.24**	RAURD 32/Vardan	25.63**
			RAURD 32/Vardan	1.40**	RAURD 34/Vardan	14.45**	RAURD 34/Vardan	23.75**
		F2	RAURD 34/JD-6	1.56**	EC 399788/Vardan	22.15**	RAURD 34/JD-6	16.85**
			RAURD 78/Pusa Bold	0.98**	EC 401574/Vardan	21.79**	RAURD 32/Vardan	13.26*
			-	-	EC 399788/Pusa Bold	19.94**	EC 401574/Vardan	12.71*
10	Siliqua density	F1	RAURD 172/JD-6	0.23**	RH-30/Vardan	23.01**	RH-30/Rajendra Sufalam	36.17**
			RH-30/Rajendra Sufalam	0.12*	-	-	RH-30/Vardan	31.61**
			-	-	-	-	RAURD 32/JD-6	31.61**
		F2	RAURD 172/Pusa Bold	0.34**	RAURD 172/Pusa Bold	68.80**	RAURD 172/Pusa Bold	109.57**
			RAURD 214/Pusa Bold	0.31**	RAURD 214/Pusa Bold	40.30**	RAURD 214/Pusa Bold	74.39**
			EC 399788/Rajendra Sufalam	0.21**	EC 399788/Vardan	32.85**	-	-
11	Biological yield per plant	F1	RH-30/Vardan	38.90**	EC 401574/Rajendra Sufalam	92.77**	EC 401574/Rajendra Sufalam	30.18**
			EC 401574/Rajendra Sufalam	26.60**	EC 399788/JD-6	77.85**	RAURD 214/Rajendra Sufalam	20.78**
			RAURD 153/Pusa Bold	23.38**	EC 399788/Rajendra Sufalam	62.56**	RAURD 214/Pusa Bold	19.78**
		F2	RAURD 78/Rajendra Sufalam	33.05**	RAURD 172/JD-6	45.46**	-	-
			RAURD 214/Vardan	18.05**	-	-	-	-
			RAURD 153/JD-6	15.38**	-	-	-	-
12	Harvest index	F1	RAURD 214/Pusa Bold	5.59**	EC 399788/Vardan	53.56**	RAURD 78/Pusa Bold	58.19**
			RAURD 78/Pusa Bold	5.45**	RAURD 153/Vardan	53.48**	EC 401574/Rajendra Sufalam	56.31**
			RH-30/Rajendra Sufalam	5.18**	RAURD 214/Pusa Bold	49.15**	RAURD 214/Pusa Bold	51.18**
		F2	RAURD 214/JD-6	16.37**	RAURD 34/Pusa Bold	89.05**	EC 401574/JD-6	108.02**
			EC 399788/JD-6	14.83**	RAURD 214/JD-6	66.83**	EC 399788/JD-6	106.38**
			RAURD 170/Vardan	12.82**	RAURD 170/Vardan	65.72**	RAURD 170/Vardan	102.52**
13	Seed yield per plant	F1	RAURD 214/Pusa Bold	10.25**	RAURD 32/JD-6	88.59**	EC 401574/Rajendra Sufalam	103.76**
			RAURD 78/Pusa Bold	9.31**	RAURD 214/Pusa Bold	86.16**	RAURD 214/Pusa Bold	82.22**
			RAURD 170/Vardan	6.11**	EC 401574/Rajendra Sufalam	82.51**	RAURD 78/Pusa Bold	66.71**
		F2	RAURD 78/Rajendra Sufalam	8.24**	RAURD 32/Pusa Bold	76.00**	EC 401574/Pusa Bold	31.56**
			EC 399788/JD-6	6.93**	EC 399788/JD-6	72.95**	EC 399788/JD-6	27.89**
			RAURD 214/JD-6	6.45**	RAURD 172/Pusa Bold	70.57**	RAURD 32/Pusa Bold	21.10**

399788/ Rajendra Sufalam for number of siliqua per plant, RAURD32/JD-6, RAURD 214/Pusa Bold and EC 401574/ Rajendra Sufalam for seed yield per plant and EC399788/ Pusa Bold, EC 399788/ Rajendra Sufalam, EC 401574/ Rajendra Sufalam for number of secondary braches per plant, respectively. Among these crosses only one hybrid i.e. EC 401574/Rajendra Sufalam had showed highly siginificant heterobeltiosis for number of siliqua per plant followed by seed yield per plant and number of secondary braches per plant. In the present study heterosis for main shoot length, days to maturity and days to 50% flowering were lower and negative in most of the crosses, which in turn can limit heterosis for seed yield. It was evident from the two analyses that additive and non-additive gene effects are important for the inheritance of different characters studied. However, the relative magnitude of non-additive was higher than additive component for all the characters in both the populations, similar to the earlier findings by Vaghela *et al.* (2011), Azzinia (2012) and Meena *et al.* (2017).

The lines EC401574, Pusa Bold and Rajendra sufalam for seed yield and number of siliqua on main raceme, RAURD 153, RAURD 34 and RAURD 32 for days to flowering and main shoot length, EC 399788 number of siliquae per plant and number of secondary branches per plant, were good general combiners. Utilization of these lines in breeding programmes may prove useful for improvement of yield and other component characters. The hybrid RAURD 153 x Pusa Bold for number of primary branches per plant, EC 399788 x Pusa Bold for secondary branches per plant, EC 401574/ Rajendra Sufalam for seed yield per plant, number of siliqua per plant and siliqua on main raceme, RAURD 214/ Rajendra Sufalam for siliqua length and RAURD 32/Vardan for seeds per siliqua manifested high sca as well as heterotic effects. Desirable significant heterosis for seed yield and component traits in Indian mustard were earlier reported by many workers (Ram *et al.*, 1976; Banga and Labana, 1984; Hirve and Tiwari, 1992; Verma, 2000; Aher *et al.*, 2009; Verma *et al.*, 2011; Meena *et al*., 2015) using different sets of materials.

Such crosses are expected to throw better segregants for yield and its components in the subsequent generations which can be exploited effectively for mustard improvement. Analysis of combining ability and heterosis depicted the importance of both additive and non-additive components in the inheritance of yield and other characters. Therefore, breeding procedures like repeated crossing and modified recurrent selection in the segregating generations may prove useful in improving seed yield, other contributing traits in Indian mustard.

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