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Assessment of heterobeltiosis and useful hererosis for seed yield and its components in (*Brassica juncea* L.)

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Abstract

Ninety six crosses of Indian mustard [*Brassica juncea* (L.) Czern & Coss.] obtained by crossing of forty eight lines with two testers in a line x tester fashion were used to assess the possibility of estimating the amount of heterosis for seed yield, yield components and oil content. These parents and crosses were grown in randomized complete block design replicated thrice and observations were taken on days to maturity, plant height at maturity (cm), number of branches plant^{-1}, number of siliquae plant^{-1}, seed yield plant^{-1} (g), and oil content (%). Heterosis of higher magnitude was expressed for seed yield plant^{-1} and number of siliqua plant^{-1}. The crosses ACN-9 x ACN-169 and Pusa bold x ACN-164 were identified as the superior crosses which can be utilized for development of high yielding genotypes.

Key words*: *Mustard, heterosis, heterobeltiosis and useful heterosis

Introduction

Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm (*Elaeis guineensis Jacq*.) oil. Among the seven edible oilseeds cultivated in India, rapeseed-mustard (*Brassica spp*.) contributes 28.6% in the total production of oilseeds. In India, it is the second most important edible oilseed after groundnut sharing 27.8% in the India's oilseed economy. The share of oilseeds is 14.1% out of the total cropped area in India, rapeseed-mustard accounts for 3%. Indian mustard (*Brassica juncea*) is largely self pollinated crop but certain amount (5-18%) of cross pollination may take place (Labana and Banga, 1984).

Heterosis breeding could be potential alternative for achieving quantum jump in production and productivity. The heterosis component is largely dependent on diverse parents with good general combining ability (gca) high. Selection of desirable heterotic crosses at an early stage is very important in developing high-yielding genotypes. Hence, the present study was aimed to select cross F_1 generation which can be forwarded further generations.

Materials and Methods

The study was conducted during the year 2013-14 at experiment farm of Agricultural Botany Section, College of Agriculture, Nagpur, India**.** During *Rabi* 2013-14, 96 crosses, where obtained by crossing 48 lines with two testers in L x T mating design. Crossed seeds of these 96 hybrids crosses, along with 50 parents were planted in randomized block design with three replications with plot size 0.45 x 0.3 m. Recommended package of practices were followed to raise a good crop . The data were recorded on five randomly selected plants from each genotype on following six characters *viz.*, days to maturity, plant height at maturity (cm), number of branches plant^{-1} , number of siliqua plant^{-1}, seed yield plant^{-1} (g) and oil content (%).

Results and Discussion

Heterosis breeding has been extensively exposed and utilized for increasing yield in a number of crops particularly cross pollinated crops. The heterosis observed in these crosses justifies the development of commercial hybrid in Indian mustard. In order to explode the hybrid vigor at commercial level, attempt

Table 1: Analysis of variance for the experimental design

Sources	d.f	Days to 50% flowering	Days to maturity	Plant height at maturity(cm)	Number of branches plant^{-1}	Number of silliqua plant^{-1}	Seed yield plant^{-1}
Replication	2	24.35	51.50	288.68	0.57	281.84	2.30
Treatments	145	21.96**	24.49**	433.67**	0.47**	1907.74**	30.02**
Parents	49	24.49**	19.94**	450.21**	0.56**	7733.76**	31.80**
Crosses	95	20.33**	21.13**	429.08**	0.37**	9128.42**	29.35**
Parents vs. crosses	1	53.36**	567.51**	59.35	5.90**	74467.93**	6.69**
Error	290	2.95	3.89	98.24	0.12	198.00	2.24

** = significant at 1% level

Table 2: Heterobeltiosis (H_1), and useful heterosis (H_2) for various characters

Crosses	Days to maturity		Plant height at maturity plant^{-1}		Number of branches plant^{-1}		Number of silique plant^{-1}		Seed yield plant^{-1}	
	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
ACN -9 X ACN-141	0.96	1.61	17.30**	17.30**	-1.01	-2.00	37.61**	78.01**	-28.73	-36.92**
ACN -9 X ACN-142	0.00	0.65	18.64**	18.64**	3.03	2.00	-14.41**	100.59**	77.95**	33.46*
ACN -9 X ACN-143	-1.92	-1.28	0.92	0.92	31.48**	-26.00**	-30.47**	6.89	-41.84**	-32.69*
ACN -9 X ACN-144	-0.32	0.33	-2.49	-2.49	-30.08**	-14.00	-13.06*	28.35**	10.98	5.00
ACN -9 X ACN-145	3.52*	4.19**	2.99	2.99	-11.11	-12.00	-7.77	40.20**	28.72	-3.46
ACN -9 X ACN-146	032	0.96	12.61*	12.61*	-11.67	6.00	-5.91	65.84**	-2.85	3.46
ACN -9 X ACN-147	0.00	0.65	3.61	3.91	-0.95	4.00	5.81	48.72**	-18.39	-18.08
ACN -9 X ACN-148	-1.27	-0.64	-0.97	-0.97	1.96	4.00	-2.26	48.45**	2.23	7.69
ACN -9 X ACN-149	0.00	0.65	2.07	2.07	2.86	8.00	-37.58	36.23**	-22.34	-18.46
ACN -9 X ACN-150	1.27	1.93	-0.88	-0.87	-24.32**	-16.00	-30.19	52.55**	-39.25**	-20.58
ACN -9 X ACN-151	-2.23	-1.60	19.46**	19.47**	-6.67	12.00	12.20**	113.79**	45.08**	75.77**
ACN -9 X ACN-152	2.23	2.89	12.88**	12.89*	-3.60	7.00	-19.30**	74.40**	-11.25	18.08
ACN -9 X ACN-153	-.32	0.33	5.66	5.66	-6.67	-2.00	12.73**	117.85**	-32.13**	-13.08
ACN -9 X ACN-154	1.60	2.26	15.78**	15.78**	-1.01	-2.00	38.86**	66.97**	6.78	-14.62
ACN -9 X ACN-155	0.64	1.29	2.44	2.44	-18.70**	0.00	50.05**	112.44**	-5.50	26.15
ACN -9 X ACN-156	-2.56	-1.93	8.88	8.88	15.15	14.00	-0.43	46.78**	4.76	1.54
ACN -9 X ACN-157	-1.60	0.96	9.29	9.30	12.61	31.00**	15.27**	75.12**	32.21*	2.69
ACN -9 X ANC-158	0.31	0.96	8.28	2.02	-3.42	-2.00	48.75*	126.09**	100.51**	50.38**
ACN -9 X ACN-159	6.07**	6.75**	23.03**	20.11**	4.90	16.00	33.57**	74.76**	76.87**	63.46**
ACN -9 X ACN-160	3.19*	3.86*	20.32**	14.27*	9.91	10.00	119.12**	163.99**	-21.08	-4.62
ACN -9 X ACN-161	1.60	2.26	29.06**	21.63**	15.15	14.00	22.65**	54.30**	-15.36	-0.38
ACN -9 X ACN-162	-2.88	-2.25	25.82**	19.97**	27.27**	26.00**	67.80**	88.73**	18.78	60.77**
ACN -9 X ACN-163	-2.23	-1.60	17.21**	17.21**	-11.71	-2.00	20.39**	66.83**	46.10**	46.15**
ACN -9 X ACN-164	-1.92	-1.28	6.92	6.72	15.15	14.00	86.44**	107.98**	192.53**	46.15**
ACN -9 X ACN-165	-1.27	-0.64	6.16	6.17	8.57	14.00	51.73**	149.03**	55.70**	66.54**
ACN -9 X ACN-166	-1.92	-1.28	6.58	6.58	-2.86	2.00	34.04**	69.90**	8.85	23.46
ACN -9 X ACN-167	0.96	1.61	10.21	10.22	13.13	12.00	-25.33**	30.87**	0.40	6.92
ACN -9 X ACN-168	0.96	1.61	6.12	6.12	-14.29	-10.00	-16.35**	29.47**	4.48	-19.23
ACN -9 X ACN-169	-2.23	-1.60	8.05	8.05	-17.07*	2.00	15.80**	85.13**	-20.46**	79.23**
ACN -9 X ACN-170	-0.96	-0.32	-5.98	-5.98	-11.71	-2.00	-24.62**	33.57**	24.84	14.23
ACN -9 X ACN-171	-0.64	0.00	13.53*	13.53*	12.38	15.52*	-4.01	83.19**	55.76**	56.47**
ACN -9 X ACN-172	-2.23	-1.60	17.38**	12.52	19.61*	22.00	20.02**	63.36**	95.67**	53.08**
ACN -9 X ACN-173	-0.64	0.00	32.49**	24.62**	9.09	8.00	18.22*	42.00**	-21.07	-3.46
ACN -9 X ACN-174	0.32	0.96	5.15	5.15	36.36**	35.00**	47.25**	101.17**	91.77**	104.23**
ACN -9 X ACN-175	0.32	0.96	31.43**	14.91*	17.17*	16.00	70.86**	102.03**	-14.92	-1.54
ACN -9 X ACN-176	0.96	1.61	15.78**	15.78**	15.15	14.00	15.97*	60.93**	-0.73	9.62
ACN -9 X ACN-177	0.00	0.65	8.74	8.74	13.98	6.00	20.55**	42.09**	36.25**	47.31**
ACN -9 X ACN-178	4.20**	3.54*	7.54	7.55	-4.76	0.00	15.94**	74.00**	2.71	47.31**

ACN -9 X ACN-179	0.96	1.61	-2.80	-3.08	-8.11	2.00	63.87**	100.18**	30.80	3.08
ACN -9 X ACN-180	3.19*	3.86*	7.18	7.18	-13.51	-4.00	-30.01**	43.44**	-21.04	-32.31*
ACN -9 X ACN-181	5.11**	5.79**	5.93	5.94	-8.77	4.00	106.96**	174.58**	98.97**	49.23**
ACN -9 X ACN-182	1.27	1.93	7.48	7.13	14.29	20.00*	91.04**	112.57**	148.72**	86.54**
ACN -9 X ACN-183	1.28	1.61	15.25**	7.50	12.96	22.00*	22.27**	118.97**	102.05**	51.54**
ACN -9 X ACN-184	0.64	1.29	28.83**	19.70**	13.13	12.00	98.25**	119.78**	103.12**	55.38**
ACN -9 X ACN-185	-1.60	-0.96	18.64**	16.01**	-5.05	-6.00	61.61**	83.15**	74.87**	31.15*
ACN -9 X ACN-186	1.60	2.23	19.46**	19.47**	-4.27	12.00	39.13**	130.96**	21.56*	95.38**
ACN -9 X ACN-187	3.83**	4.51**	18.31**	18.32**	-18.10*	-14.00	17.30**	68.77**	36.92*	2.69
ACN -9 X ACN-188	1.92	2.58	14.13*	14.13*	5.88	8.00	24.38**	71.47**	53.75**	39.62**
Pusa bold X ACN-141	3.86*	3.86**	13.94*	13.99*	-1.01	-2.00	13.28*	50.34**	48.02**	48.08**
Pusa bold X ACN-142	4.82**	4.82**	8.47	8.51	11.11	10.00	-25.46**	77.47**	28.41*	28.46*
Pusa bold X ACN-143	3.22*	3.22*	14.12*	14.17*	-5.56	2.00	23.83**	73.55**	100.73**	132.31**
Pusa bold X ACN-144	3.86*	3.86*	18.72**	18.78**	-23.58**	-6.00	22.20**	71.65**	9.57	9.62
Pusa bold X ACN-145	3.86*	3.86*	15.37**	15.42**	19.19*	18.00*	11.67*	65.21**	48.79**	48.85**
Pusa bold X ACN-146	2.58	2.58	15.69**	15.74**	-1.67	18.00*	8.90*	88.55**	28.93*	37.31**
Pusa bold X ACN-147	1.61	1.61	22.59**	22.64**	20.00**	26.00**	39.18**	88.82**	37.55**	38.08**
Pusa bold X ACN-148	4.82**	4.82**	14.03*	14.08*	19.61*	22.00*	1.70	53.58**	25.96	32.69*
Pusa bold X ACN-149	4.51**	4.51**	9.98	10.03	-6.67	-2.00	-37.70**	36.01**	-15.75	-11.54
Pusa bold X ACN-150	6.12**	6.12**	22.13**	22.18**	-15.32*	-6.00	-42.36**	29.70**	91.82**	150.77**
Pusa bold X ACN-151	4.82**	4.82**	16.15**	16.20**	-21.90**	-18.00*	-17.47**	62.96**	-22.86*	-6.54
Pusa bold X ACN-152	4.51**	4.51*	16.88**	16.94**	-2.70	8.00	34.24**	175.80**	30.67**	73.85**
Pusa bold X ACN-153	3.22*	3.22*	8.28	8.33	-20.00	-16.00	-50.23**	8.20	-7.21	18.85
Pusa bold X ACN-154	1.93	1.93	8.60	8.65	-1.01	-2.00	-13.25	12.39	-6.57	-6.54
Pusa bold X ACN-155	8.36**	8.36**	18.68**	18.73**	-18.70**	0.00	-5.77	41.42**	-28.26**	-4.23
Pusa bold X ACN-156	6.75**	6.75**	14.81**	14.86**	-5.05	-6.00	11.57	61.87**	-20.42	-20.38
Pusa bold X ACN-157	3.22*	3.22*	2.44	2.49	-18.92*	-10.00	-7.43	31.64**	-9.27	-9.23
Pusa bold X ACN-158	0.00	0.00	4.78	3.96	17.95*	-4.00	-44.58**	16.72**	-23.11	-23.08
Pusa bold X ACN-159	2.89	2.89	4.52	-2.02	-1.96	0.00	-5.93	35.20**	0.73	0.77
Pusa bold X ACN-160	0.00	0.00	19.15**	17.40**	-11.71	-2.00	15.52**	51.69**	37.04**	45.00**
Pusa bold X ACN-161	1.29	1.29	26.03**	18.78**	3.03	2.00	18.65**	49.98**	13.73	33.85*
Pusa bold X ACN-162	0.00	0.00	12.94	7.69	1.01	0.00	10.49	31.64**	-49.08**	-31.08*
Pusa bold X ACN-163	0.33	0.33	10.81	10.86	-11.71	-2.00	-21.77**	15.95*	-2.35	-2.31
Pusa bold X ACN-164	0.00	0.00	11.30*	11.09*	7.53	0.00	26.51**	30.15**	43.79**	43.85**
Pusa bold X ACN-165	8.36**	8.36**	12.42*	12.47*	-4.76	0.00	-30.00	26.50**	-9.03	-2.69
Pusa bold X ACN-166	4.19**	4.19**	8.97	9.02	-4.76	0.00	-6.88	24.61**	-2.68	10.38
Pusa bold X ACN-167	8.36**	8.36**	8.47	8.51	-21.21*	-22.00*	-35.67**	15.73*	-1.77	4.62
Pusa bold X ACN-168	5.47**	5.47**	3.04	3.08	-8.57	-4.00	-13.55*	33.08**	-22.34	-22.31
Pusa bold X ACN-169	7.40**	7.40**	16.70	16.75**	-18.70**	0.00	-45.05**	28.30**	-68.56**	-27.69*
Pusa bold X ACN-170	7.40**	7.40**	2.65	2.69	-26.13**	-18.00*	-40.48**	10.00	-19.65	-19.62
Pusa bold X ACN-171	8.05**	8.05**	-2.80	-2.76	-31.43**	-28.00**	-55.74**	-3.92	-34.11**	-18.65
Pusa bold X ACN-172	7.08**	7.08**	-4.70	-8.65	-17.65	-16.00	-25.40**	9.69	4.77	4.81
Pusa bold X ACN-173	6.12**	6.12**	7.78	1.38	43.43**	42.00**	19.99**	43.80**	-25.47	-8.85
Pusa bold X ACN-174	5.47**	5.47**	5.71	5.75	-9.09	-10.00	-24.88**	13.38	-37.88**	-33.85*
Pusa bold X ACN-175	6.75**	6.75**	-0.15	-12.70	9.09	8.00	-27.39**	-1.76	-25.56**	-13.85
Pusa bold X ACN-176	6.75**	6.75**	5.84	5.89	8.08	7.00	-7.65	32.54**	-18.84	-10.38
Pusa bold X ACN-177	7.40**	7.40**	8.05	8.10	5.05	4.00	84.57**	83.24**	-21.74	-15.38
Pusa bold X ACN-178	8.74**	8.05**	8.56	8.61	-4.76	0.00	-10.93	38.67**	-54.41**	-34.62*
Pusa bold X ACN-179	4.19**	4.19**	-4.89	-5.20	-13.51	-4.00	38.97**	73.32**	40.72**	40.77**
Pusa bold X ACN-180	5.47**	5.47**	5.02	5.06	-2.70	8.00	-1.27	93.51**	5.73	5.77
Pusa bold X ACN-181	5.79**	5.79**	-0.83	-0.78	-22.81**	-12.00	6.67	51.96**	-28.10*	-28.08*
Pusa bold X ACN-182	6.43**	6.43**	-3.60	-3.91	-21.90	-18.00*	115.05**	132.81**	19.95	20.00
Pusa bold X ACN-183	4.82**	4.82**	1.93	-4.92	-16.67**	-10.00	-29.89**	34.75**	-15.42	-15.38
Pusa bold X ACN-184	6.43**	6.43**	18.33**	9.94	-19.19*	-20.00*	25.77**	28.66**	-2.35	-2.31
Pusa bold X ACN-185	6.75**	6.75**	4.33	1.98	-11.11	-12.00	29.95**	29.65**	-9.65	-9.62
Pusa bold X ACN-186	8.05**	7.45**	-7.73	-7.69	-12.82	2.78	-20.78**	40.78**	-46.16**	-16.55
Pusa bold X ACN-187	7.08**	7.08**	7.78	7.82	-21.90**	-18.00*	-32.57	6.17	-18.88	-18.85
Pusa bold XACN-188	7.08**	7.08**	14.58**	14.63**	-5.88	-4.00	40.04**	90.36**	-3.50	-3.46
C.D. at 1%	4.17	4.17	20.97	20.97	0.74	0.74	29.78	29.78	3.16	3.16
C.D.at5%	3.17	3.17	15.92	15.92	0.56	o.56	22.61	22.61	2.40	2.40
SE(m)	2.59	2.59	65.47	65.47	0.08	0.08	132.02	132.02	1.49	1.49

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

should be made to convert high yielding heterotic parents into cytoplasmic male sterile lines and search for fertility restorer lines in the germplasm to develop mustard hybrid.

Data in table 1 revealed that the mean squares due to replication were non significant for plant height at maturity, number of siliqua plant^{-1} and seed yield plant^{-1}. Treatment differences were significant for all the traits studied. Kang *et al.* (2013) reported that analysis of variance for various characters showed significant differences in different parents for all the traits. Similar results of significant mean sum of square of parents and crosses for all the traits studied were also reported by Rameeh (2012). Significant differences among parents and hybrid in F_1 for all the characters except 1000 seed weight were also reported by Sincik *et al.* (2011). Vaghela *et al.* (2011) also reported significant differences among genotypes for all the characters studied.

The cross Pusa bold X ACN-150 was identified to exhibit maximum useful heterosis of (150.77%) and (91.82%) heterobeltiosis for seed yield plant^{-1}. The same cross also possessed useful heterosis of (29.70%) for number of siliqua plant^{-1}. Another cross Pusa bold X ACN-143 recorded significant useful heterosis (132.31%) and heterobeltiosis (100.31%) for seed yield plant^{-1}. The same cross also possessed significant useful heterosis (73.55%) and heterobeltiosis (23.83%) for number of siliqua plant^{-1}. Another cross exhibiting significant useful heterosis for seed yield plant^{-1} are ACN-9 X ACN-174 (H_1 91.77 % H_2 104.23%). The same cross also showed significant useful heterosis and heterobeltiosis for number of siliqua plant^{-1} (H_2 101.17%, H_1 47.25%) and number of branches plant^{-1} (H_2 35.00%, $H_1$36.36%). ACN-9 X ACN-159 had significant useful heterosis and heterobeltiosis for seed yield plant^{-1} (H_2 63.46%, H_1 76.87%,) and number of sliqua plant^{-1} (H_2 74.76%, $H_1$33.57%). This was followed by ACN-9 X ACN-182 which possessed useful heterosis and heterobeltiosis for seed yield plant^{1} ($H_2$86.54%, $H_1$148.72%), Number of siliqua plant^{1} ($H_2$112.57%, $H_1$91.04), number of branches plant^{-1} (H_2 20.00%,H_1 14.29%). Significant useful heterosis and heterobeltiosis were exhibited by the cross ACN-9 X ACN-183 ($H_2$51.54%, $H_1$102.05%), number of siliqua plant^{-1} ($H_2$118.97%, $H_1$22.27%). Notable amount of heterosis for seed yield plant^{-1} (104.3%) and number of siliqua plant^{-1} (39.03) were also reported by Joshi (2001), Katiyar *et al.* (2005) reported heterosis upto (91.6%) over better parents (90.5%) over check varieties for seed yield. Wassu (2011) reported standard heterosis apto (191.57%) for number of pod plant^{-1} while, (16.64 to 66.09%) for seed yield plant^{-1}. Results of high heterosis for seed yield plant^{-1} contributing traits were also reported by Ghosh *et al.* (2002). The level of heterosis observed in these crosses justifies the development of commercial hybrid in Indian mustard. Commercial exploitation of hybrid in *Brassica juncea* has been reported by many mustard workers like Meena *et al.* (2014, 2015). Akbar *et al.* (2007) also reported that crosses with positive heterosis and heterobeltosis may be utilized for hybrid seed production by cms and restorer lines.

Heterosis has positive association with the sca effects. Sca effects of crosses revealed that the crosses ACN-9 X ACN-169 and Pusa bold X ACN-164 exhibited significant positive sca effects seed yield plant^{-1} and number of branches plant^{-1} while, the crosses Pusa bold x ACN-169, ACN-9 X ACN-184 and ACN-9 X ACN-164 exhibited significant negative sca effects seed yield plant^{-1} and number of siliqua plant^{-1}. Maha (2008) also concluded that sca effects showed wide variation in the level of significant for different character studied.

Heterotic crosses showing substantial and significant sca effects for seed yield and number of siliqua plant^{-1} over mid, better parent and over check varieties are indicated table 3. Dixit *et al.* (2005) reported that the crosses showing heterobeltiosis for seed yield plant^{-1} possessed significant and positives sca effects. Similar results of significant correlation between heterosis for seed yield and mean performance of the crosses were reported by Rameeh (2012). Aher *et al.* (2009) found that the promising hybrid also had high *per se* performance and significant desirable sca effects for various characters.

From data of heterobeltiosis and useful heterosis, it was observed that crosses with high magnitude of heterosis had higher magnitude of sca effects and better *per se* performance. Hence selection of superior crosses for development of hybrids should necessarily base not only on the magnitude of heterosis, but also high mean performance and high

Table 3: Superior crosses showing high heterosis (H_1, H_2 and H_3), high sca and high mean for number of seed yield plant^{-1} and number of siliqua plant^{-1}

Crosses	Seed yield plant^{-1}				Number of siliqua plant^{-1}			
	Mean	sca	H_1	H_2	Mean	sca	H_1	H_2
ACN-9 X ACN-169	15.53**	6.09**	_	79.23**	242.00**	79.26**	15.80**	85.13
Pusa bold X ACN-164	12.47**	3.84**	43.79**	43.85**	160.67	43.73	26.51**	30.15**

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

sca effects. The first cross ACN-9 X ACN-169 exhibited significant useful heterosis (H_2) for seed yield plant^{-1}. The same cross also exhibited significant sca and mean for seed yield plant^{-1} and number of siliqua plant^{-1} and significant heterosis in to ($H_1$and H_2) for number siliqua plant^{-1}. Another cross Pusa bold x ACN-164 also exhibited significant desirable heterosis (H_1 and H_2) for seed yield as well as number of siliqua plant^{-1}, significant sca for seed yield and number of siliqua plant^{-1} and significant mean for seed yield plant^{-1}. These crosses after their evaluation in trials can be used for development of hybrids after conversion of female line in to CMS background and male parents as restorers.

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