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HETEROSIS FOR SEED AND YIELD CONTRIBUTING CHRACHTERS IN MUSTARD (*Brassica* species)

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ABSTRACT

Forty two F_1 crosses of mustard (*Brassica juncea* L.) were obtained by full diallel mating design using seven parents and F_1 hybrids along with parents (Kranti was used as parent as well as check) during *rabi* 2019-20 and were evaluated to estimate the heterobeltiosis and useful heterosis of crosses for seed yield and yield contributing characters. The parents and crosses were grown in randomized block design replicated thrice at Research field of AICRP (Linseed and Mustard), College of Agriculture, Nagpur during *rabi* 2020-21 and observations were taken on days to first flower, days to maturity, plant height (cm), number of branches plant^{-1}, number of siliquae plant^{-1}, siliquae density on main branch, 1000 seed weight (g) and seed yield plant^{-1} (g). The crosses Kranti x NRCHB-101, TAM 108-1 x BIO-902, NRCHB-101x PC-6, TAM 108-1 x PC-6 and PC-6 x TAM 108-1 had high mean performance and exhibited significant standard heterosis over the superior check for yield and most of its contributing characters. These crosses were identified as superior crosses, which can be utilized for development of hybrid varieties after evaluation in yield trial and converting female lines into male sterile lines.

(Key words: Indian mustard, full diallel, heterobeltiosis, useful heterosis)

INTRODUCTION

Agriculture is the basic foundation of economic development. Oilseed crops are the second most important determinant of agricultural economy, after cereals. Mustard is the second most important oilseed crop in India after Soybean. It accounts for nearly 20-22% of the total oilseeds produced in the country (Anonymous, 2018). Indian mustard *(Brassica juncea)* is called as "rai", "raya" or "laha" is one of the important oilseed crops belongs to family *Cruciferae* (*Syn. Brassicaceae)* and genus *Brassica*. Indian mustard or brown mustard, [*Brassica juncea (L.)* Czern & Coss] genome content AABB is a natural amphidiploids (2n = 36) of *Brassica rapa* (2n = 20) and *Brassica nigra* (2n = 16). *Brassica carinata* (Ethiopian rape, Ethiopian mustard, Abyssinian mustard) is a member of the genus *Brassica*. *Brassica carinata* is an amphiploid species. Mustard is primarily grown in India for extraction of oil.

India predominates other countries in terms of area under production of oilseeds but lacks behind in terms of yield. On the other hand, the demand of edible oils is increasing very rapidly with increasing population and has been estimated to be 20.20 million tones for year 2020, 28.40 million tones for the year 2030 and 41.6 million tones for the year 2050. (Arvind Kumar, 2017). Considering the low production in Vidarbha region as compared to India, there is need of producing high yielding varieties with early maturity, high oil content, terminal heat tolerance and powdery mildew resistance varieties. Study on heterosis is useful in deciding the direction and prospects of future improvement programme, which might be more promising than the conventional breeding programme.

MATERIALS AND METHODS

The experimental material comprising of seven genotypes including five genotypes of Indian mustard (*Brassica juncea*) and two genotypes of Ethopian mustard (*Brassica carinata*) were crossed in diallel mating design including reciprocals to obtain 42 crosses during rabi 2019-20. Forty two F_{1s} along with 7 parents (where Kranti was used as parents as well check) were evaluated in randomized block design at Research field of AICRP (Linseed and Mustard), College of Agriculture, Nagpur during rabi 2020-21. Observations were taken on days to first flower, days to maturity, plant height (cm), number of branches plant^{-1}, number of siliquae plant^{-1}, siliquae density on main branch, 1000 seed weight (g) and seed yield plant^{-1}(g). The data pertaining to various characters were analyzed as per the procedure of RBD given by Panse and Sukhatme (1978).

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The hybrid performance (%) tested in comparison with better parent (Heterobeltosis) and check (useful heterosis) was calculated as per the formulae given by Fonseca and Patterson (1968) and Meredith and Bridge (1972) respectively.

RESULTS AND DISCUSSION

The analysis of variance for heterosis was estimated for days to first flower, days to maturity, plant height (cm), number of branches plant^{-1}, siliquae density on main branch, number of siliquae plant^{-1}, 1000 seed weight and seed yield plant^{-1} and data are presented in Table 1. The mean squares due to genotypes, parents, crosses and parents vs crosses were significant for all the eight characters under study except for number of siliquae plant^{-1} for parents vs crosses. The variation due to genotypes was further partitioned into variation due to parents, crosses and parent vs crosses. Parents exhibited significant difference for all characters. The mean squares due to crosses exhibited significant difference for all characters. The mean squares due to parent vs crosses exhibited significant difference for all characters except number of siliquae plant^{-1}. Similar results were also observed by Vaghela *et al.* (2011), Saikia *et al.* (2019) Sapkal *et al.* (2021) and Raut *et al.* (2021) for seed yield and it's contributing characters. The above scientists concluded the presence of variability among genotypes from the significant mean squares due to genotypes, parents, crosses and parents vs crosses.

It was observed that twelve crosses were found to be significant over check Kranti for days to first flower in the desirable direction. Useful heterosis over the check Kranti was found to be significant in the desirable direction in seven crosses for days to maturity in which ACN-09 x Kranti (-4.37%) exhibited highest useful heterosis. Thirty three crosses were recorded for negative significant useful heterosis over the check Kranti for plant height. Maximum desirable negative significant useful heterosis was recorded in the cross TAM 108-1 x PC-5 (-31.51 %). For number of branches positive significant useful heterosis over the check Kranti was noticed in nine crosses. Five crosses exhibited positive significant useful heterosis over superior check Kranti for number of siliquae plant^{-1}. Highest magnitude of useful heterosis over superior check Kranti was observed in the cross Kranti x NRCHB-101 (43.14 %) and twenty six crosses showed negative significant useful heterosis over superior check Kranti for number of siliquae plant^{-1}. Among the 42 crosses, none of the crosses exhibited positive significant useful heterosis over superior check Kranti for siliquae density on main branch. For 1000 seed weight, twenty one crosses exhibited positive significant useful heterosis, while twenty crosses had negative significance over the check Kranti. The cross combination of NRCHB-101 x ACN-09 (14.09%) had shown highest positive significant useful heterosis over superior check Kranti. For seed yield plant^{-1}, eight crosses possessed positive significant useful heterosis, while ten crosses exhibited negative significant over superior check Kranti. Most promising cross exhibiting highest positive significant useful heterosis over superior check Kranti was the cross NRCHB-101 x PC-6 (80.76 %) followed by Kranti x NRCHB-101 (74.33 %) and NRCHB-101 x Kranti (62.89 %). Significant positive heterosis for seed yield plant^{-1} in mustard in their study were noted by earlier workers Mohammed *et al.* (2011), Kumar *et al.* (2013), Nausheen *et al.*(2015), Sapkal *et al.* (2021) and Raut *et al.* (2021).

Effective utilization of heterosis to develop high yielding hybrids is one of the most important objectives of *Brassica* breeding In India. Considering the high mean performance, significant useful heterosis in desirable direction five potential crosses were identified for their exploitation from 42 crosses and data are given in Table 2. The hybrid Kranti x NRCHB-101was identified as best hybrid as it was significantly superior over Kranti for seed yield plant^{-1} and exhibited highly significant positive useful heterosis over Kranti for seed yield plant^{-1}, number of siliquae plant^{-1} and 1000 seed weight. The hybrid TAM 108-1 x Bio-902 was significantly superior over the check Kranti for seed yield plant^{-1} and exhibited highly significant positive useful heterosis over Kranti for seed yield plant^{-1}, 1000 seed weight and plant height. The cross combination NRCHB-101 x PC-6 exhibited significant superiority over the check Kranti for seed yield plant^{-1} and exhibited highly significant positive useful heterosis over the check Kranti for seed yield plant^{-1}, number of siliquae plant^{-1}, plant height and number of branches plant^{-1}. Similarly, the hybrid TAM 108-1 x PC-6 was significantly superior over the check Kranti for seed yield plant^{-1} and had highly significant positive useful heterosis over the check Kranti for seed yield plant^{-1} and plant height. Among 42 crosses studied, the cross combination PC-6 x TAM 108-1 was significantly superior over the check Kranti for seed yield plant^{-1} and also showed highly significant positive useful heterosis over the check Kranti for seed yield plant^{-1}, 1000 seed weight, number of siliquae plant^{-1}, plant height and number of branches plant^{-1}. Similarly, Meena *et al.* (2015) also identified superior crosses based on *per se* performance and significant heterosis. The selection of crosses on basis of significant heterosis and better *per se* performance was also done by Vaghela *et al.* (2011) , Saikia *et al.* (2019), Sapkal *et al.* (2021) and Raut *et al.* (2021).

Table 1. Analysis of variance for heterosis

Source Of variation	Degrees of freedom	Means squares							
		Days to first flower	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Siliquae density on main branch	Number of siliquae plant^{-1}	1000 seed weight	Seed yield plant^{-1} (g)
Replications	2	2.62	0.49	83.11	0.04	0.002	1496.93	0.01	3.78
Genotypes	48	382.55 **	126.59**	686.88**	1.11**	0.02 **	13919.80**	1.67 **	23.51**
Parents	6	307.01 **	115.39**	481.11**	0.22*	0.01**	7445.83**	1.79**	5.45**
Crosses	41	107.95**	127.08**	617.59**	1.21**	0.02**	15200.64**	1.65**	26.35**
Parent Vs crosses	1	12094.63**	173.60**	4762.42**	2.18**	0.03**	249.02	1.50**	15.49**
Error	96	1.34	0.26	37.64	0.09	0.001	779.40	0.01	1.36

Table 3. Crosses selected for heterosis breeding on the basis of mean performance, useful heterosis over check Kranti for yield and other traits

Cross	Mean performance for seed yield plant^{-1}(g)	Useful heterosis over check Kranti for seed yield plant^{-1}(g)	Heterosis superior over the check for other characters
Kranti x NRCHB-101	17.52	74.33**	NOB, NOS, 1000SW
TAM 108-1 x BIO-902	12.89	28.23**	PH, 1000SW
NRCHB-101x PC-6	18.17	80.76**	PH, NOB, NOS, SD
TAM 108-1 x PC-6	13.07	30.02**	PH
PC-6 x TAM 108-1	15.33	52.50**	NOB, NOS, 1000SW

** = Significant at 1 % level. *= Significant at 5 % level.

DFF-Days to first flower, DM- Days to maturity, PH- Plant height (cm), PB- Number of branches plant^{-1}, NOS- Number of siliquae plant^{-1}, SD- Siliquae density on main branch and TW- Thousand seed weight (g)

Table 3. Mean performance and magnitude of useful heterosis over Kranti (H)

Crosses	Days to first flower		Days to maturity		Plant height (cm)		Number of branches plant^{-1}		Number of siliquae plant^{-1}		Siliquae density on main branch		Thousand seed weight (g)		Seed yield plant^{-1} (g)	
	Mean	**H**	**Mean**	**H**	**Mean**	**H**	**Mean**	**H**	**Mean**	**H**	**Mean**	**H**	**Mean**	**H**	**Mean**	**H**
TAM 108-1 X ACN-09	38.13	-2.39	104.40	-3.51**	122.73	-20.10**	2.93	-6.38	248.27	-25.56**	0.63	-5.60	5.01	-5.41**	8.53	-15.16
TAM 108-1 X Kranti	35.07	-10.24**	107.33	-0.80*	116.87	-23.91**	3.13	0.00	241.10	-27.71**	0.58	-12.70**	5.63	6.29**	8.46	-15.82
TAM 108-1 X Bio 902	41.67	6.66**	107.53	-0.62	137.00	-10.81**	3.00	-4.26	371.41	11.37	0.58	-13.50**	5.75	8.55**	12.89	28.23**
TAM 108-1 X NRCHB 101	38.60	-1.19	103.80	-4.07**	122.13	-20.49**	2.67	-14.89	272.34	-18.34**	0.53	-20.50**	6.03	13.71**	9.01	-10.32
TAM 108-1 X PC-6	60.20	54.10**	119.00	9.98**	125.33	-18.40**	2.60	-17.02*	337.53	1.21	0.56	-15.40**	4.99	-5.85**	13.07	30.02**
TAM 108-1 X PC-5	60.87	55.80**	118.53	9.55**	105.20	-31.51**	2.20	-29.79**	222.93	-33.15**	0.63	-5.50	4.15	-21.76**	7.94	-21.00*
ACN-09 X TAM 108-1	36.87	-5.63*	104.07	-3.82**	127.33	-17.10**	3.00	-4.26	224.40	-32.71**	0.48	-28.20**	5.53	4.28**	8.01	-20.33*
ACN-09 X Kranti	36.33	-7.00**	103.47	-4.37**	141.67	-7.77*	2.73	-12.77	225.23	-32.46**	0.62	-6.30	5.53	4.40**	7.74	-22.99*
ACN-09 X Bio 902	38.20	-2.22	104.87	-3.08**	137.87	-10.24**	3.07	-2.13	264.23	-20.77**	0.47	-30.15**	5.74	8.30**	8.80	-12.44
ACN-09 X NRCHB 101	39.07	0.00	108.67	0.43	128.87	-16.10**	2.87	-8.51	200.53	-39.87**	0.53	-20.70**	5.65	6.67**	6.55	-34.86**
ACN-09 X PC-6	57.27	46.59**	112.93	4.37**	137.27	-10.63**	2.87	-8.51	298.07	-10.62	0.57	-14.25**	5.08	-4.21**	10.13	0.76
ACN-09 X PC-5	56.33	44.20**	114.33	5.67**	134.00	-12.76**	3.53	12.77	338.33	1.45	0.68	1.40	5.05	-4.78**	11.61	15.56
Kranti X TAM 108-1	35.33	-9.56**	108.20	0.00	154.20	0.39	3.27	4.26	229.93	-31.05**	0.63	-5.00	5.89	11.07**	8.17	-18.67
Kranti X ACN-09	36.80	-5.80**	104.20	-3.70**	156.17	1.67	3.33	6.38	221.37	-33.62**	0.57	-14.60**	5.93	11.95**	7.46	-25.77
Kranti X Bio 902	37.00	-5.29**	105.67	-2.34**	146.33	-4.73	3.00	-4.26	301.30	-9.66	0.51	-23.60**	5.83	10.06**	9.65	-3.95
Kranti X NRCHB-101	43.53	11.43**	107.93	-0.25	170.00	10.68**	3.47	10.64	477.37	43.14**	0.51	-23.50**	5.45	2.89*	17.52	74.33**
Kranti X PC-6	60.33	54.44**	123.07	13.74**	114.20	-25.65**	4.67	48.94**	222.20	-33.37**	0.58	-12.60**	5.01	-5.41**	9.23	-8.13
Kranti X PC-5	61.93	58.53**	123.20	13.86**	106.00	-30.99**	3.53	12.77	235.96	-29.25**	0.39	-40.80**	5.01	-5.41**	7.86	-21.79*
Bio-902 X TAM 108-1	38.20	-2.22	107.87	-0.31	142.80	-7.03*	3.60	14.89	403.27	20.92**	0.55	-18.00**	6.01	13.33**	15.07	49.92**
Bio-902 X ACN-09	36.80	-5.80*	108.80	0.55	145.67	-5.16	2.80	-10.64	288.50	-13.49	0.50	-24.70**	5.59	5.41**	9.13	-9.12
Bio-902 X Kranti	37.67	-3.58	107.53	-0.62	148.60	-3.26	2.73	-12.77	309.73	-7.13	0.54	-18.40**	5.89	11.19**	10.28	2.29
Bio-902 X NRCHB 101	35.67	-8.70**	108.20	0.00	140.93	-8.25*	2.80	-10.64	270.55	-18.88**	0.60	-9.80*	5.99	12.96**	8.54	-15.02
Bio-902 X PC-6	60.07	53.75**	122.00	12.75**	146.73	-4.47	3.60	14.89	277.17	-16.89*	0.53	-20.70**	4.99	-5.79**	8.93	-11.18
Bio-902 X PC-5	60.87	55.80**	120.07	10.97**	136.20	-11.33**	3.47	10.64	227.47	-31.79**	0.63	-5.20	5.71	7.67**	7.63	-24.11*
Kranti X PC-5	38.13	-2.39	104.40	1.17**	122.73	-20.10**	2.93	-6.38	248.27	-25.56**	0.63	-5.60	5.01	-5.41**	8.53	-15.16

Continued Table 3.......

Crosses	Days to first flower		Days to maturity		Plant height (cm)		Number of branches plant^{-1}		Number of siliquae plant^{-1}		Siliquae density on main branch		Thousand seed weight (g)		Seed yield plant^{-1} (g)	
	Mean	H	Mean	H	Mean	H	Mean	H	Mean	H	Mean	H	Mean	H	Mean	H
NRCHB-101 X TAM 108-1	44.13	-6.63**	109.47	1.17**	138.67	-9.72**	3.07	-2.13	316.40	-5.13	0.59	-11.00*	5.14	-3.02*	10.27	2.22
NRCHB-101 X ACN-09	36.47	-22.85**	111.73	3.27**	135.13	-12.02**	2.73	-12.77	204.40	-38.71**	0.56	-16.60**	6.05	14.09**	6.41	-36.25**
NRCHB-101 X Kranti	37.07	-21.58**	112.47	3.94**	135.67	-11.68**	2.53	-19.15*	450.70	35.14**	0.63	-6.20	5.50	3.77*	16.37	62.89**
NRCHB-101 X Bio 902	37.93	-19.75**	109.27	0.99*	128.07	-16.62**	2.80	-10.64	243.30	-27.05**	0.59	-11.30**	5.52	4.15**	8.02	-20.20
NRCHB-101 X PC-6	59.13	25.11**	108.97	0.71	135.00	-12.11**	5.00	59.57**	420.27	26.02**	0.68	2.30	5.11	-3.52*	18.17	80.76**
NRCHB-101 X PC-5	61.33	29.76**	120.50	11.37**	108.20	-29.56**	3.67	17.02*	223.77	-32.90**	0.60	-10.10*	4.50	-15.09**	7.57	-24.71*
PC-6 X TAM 108-1	61.13	29.34**	120.97	11.80**	114.13	-25.69**	3.87	23.40**	417.60	25.22**	0.65	-2.60	5.91	11.57**	15.33	52.50**
PC-6 X ACN-09	59.67	26.23**	119.20	10.17**	129.13	-15.93**	4.20	34.04**	299.20	-10.28	0.38	-42.70**	4.31	-18.74**	10.19	1.43
PC-6 X Kranti	62.13	31.45**	114.00	5.36**	125.47	-18.32**	4.20	34.04**	272.47	-18.30**	0.49	-26.80**	4.85	-8.43**	8.83	-12.17
PC-6 X Bio 902	59.87	26.66**	114.03	5.39**	141.53	-7.86*	4.40	40.43**	302.57	-9.28	0.72	8.30	5.61	5.91**	9.28	-7.66
PC-6 X NRCHB-101	63.93	35.26**	124.60	15.16**	119.47	-22.22**	4.47	42.55**	371.12	11.28	0.72	8.50	5.19	-2.14	13.22	31.51**
PC-6 X PC-5	60.60	28.21**	117.80	8.87**	144.27	-6.08	2.87	-8.51	244.93	-26.56**	0.69	3.10	3.37	-36.48**	8.64	-14.03
PC-5 X TAM 108-1	61.80	30.75**	120.00	10.91**	121.67	-20.79**	3.00	-4.26	274.07	-17.82*	0.63	-5.75	4.25	-19.87**	9.09	-9.52
PC-5 X ACN-09	59.53	25.95**	112.47	3.94**	158.67	3.30	3.27	4.26	261.87	-21.48**	0.68	2.40	4.65	-12.20**	8.77	-12.70
PC-5 X Kranti	58.00	22.71**	109.67	1.36**	120.53	-21.53**	2.73	-12.77	196.00	-41.23**	0.66	-0.50	3.94	-25.66**	6.51	-35.19**
PC-5 X Bio 902	62.47	32.16**	116.97	8.10**	125.93	-18.01**	3.53	12.77	205.33	-38.43**	0.64	-4.40	3.81	-28.18**	6.83	-32.01**
PC-5 X NRCHB-101	60.53	28.07**	120.27	11.15**	124.47	-18.97**	2.47	-21.28*	239.33	-28.24**	0.57	-14.50**	4.00	-24.53**	8.17	-18.74
PC-5 X PC-6	59.60	26.09**	122.40	13.12**	131.53	-14.37**	3.73	19.15*	260.91	-21.77**	0.67	0.30	3.40	-35.91**	8.85	-11.91
Kranti	47.27		108.20		153.60		3.13		333.50		0.67		5.30		10.05	
CD (5%)	1.88		0.83		9.94		0.48		45.25		0.06		0.15		1.89	

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

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