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Heterosis and combining ability for yield and its component traits in Indian mustard [*Brassica juncea* (L.)]

P.O. Vaghela, D.A. Thakkar*, H.S. Bhadauria*, D.A. Sutariya, S.K. Parmar and D.V. Prajapati

*Main Castor-Mustard Research Station,
Sardarkrushinagar Dantiwada Agricultural University,
Sardarkrushinagar, Dantiwada, Dist Banaskantha-385506 (Gujarat) India
Corresponding author: prakash.singh018@gmail.com
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Abstract

Six parents *viz.* BPR 380-1, RSK 28, RH (OE) 0103, SKM 532, GM 3 and GM 1 were crossed in diallel fashion (excluding reciprocals) in Indian mustard (*Brassica juncea* (L.) Czern & Coss). The resultant fifteen hybrids along with six parents were evaluated in randomized block design with three replications during *Rabi* 2009. The analysis of variance for experimental design revealed that high significant differences existed among genotypes for all the characters. This indicated that considerable amount of genetic variation among parents and hybrids for all the traits. Most heterotic hybrids for seed yield per plant were RSK 28 x RH (OE) 0103 and GM 3 x GM 1. Analysis of variance for combining ability showed the significance of gca and sca variances for all the characters except oleic acid. The ratio of variance due to gca and sca was below unity for all the characters under study. The results of specific combining ability effects revealed that, the crosses, SKM 532 x GM 3, RSK 28 x RH(OE)0103 and BPR 380-1 x RSK 28 were three best cross combinations for seed yield, these crosses also showed moderate standard heterosis.

Key words: *Heterosis, combining ability, Indian mustard*

Introduction

Indian mustard belongs to family Brassicacae and genus *Brassica.* Indian mustard [*Brassica juncea* (L) Czern & Coss] is a natural amphidiploids (2n = 36) of *Brassica rapa* (2n = 20) and *Brassica nigra* (2n = 16). Mustard is largely self pollinated but certain amount (2 - 15%) of cross pollination may take place due to honeybees. It contributes more than 13 per cent to the global production of edible oil. Seed contain 38 to 40 per cent oil and is mainly utilize for human consumption throughout Northern India for cooking as well as frying purpose. A high yielding genotype may/may not transmit its superiority to its progeny. Hence, in order to develop high yielding varieties, it would be desirable to identify parents with good combining ability for different traits and the nature of gene action governing yield and their component traits, which could be of great help in selecting parents for the hybridization programme

Materials and methods

The material comprising of six genetically and geographically diverse genotypes of mustard *viz.*, BPR 380-1, RSK 28, RH(OE)0103, SKM 532, GM 3 and GM 1 were crossed in diallel fashion (excluding reciprocals) to obtain 15 single crosses. The experiment with 21 treatments comprising six parent and fifteen F_1's was laid out in randomized block design with three replications during *Rabi* 2009 at the Main Castor and Mustard Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. A single row of 4 m length of plants comprised of a treatment. The spacing between rows was 45 cm and between plants within row was 10 cm. Five randomly selected competitive plants for each plot were used for recording observations. Days to 50% flowering and days to maturity were recorded on plot basis. The experimental data recorded for various characters were analyzed as per the procedure of Panse and Sukhatme (1978), heterosis was calculated following the method of Fonseca and Patterson (1968), and combining ability analysis by employing model-I (Fixed Effect Model), Method-I of Griffing (1956).

Results and discussion

The analysis of variance for parents, hybrids and parents vs. hybrids computed for different characters under study revealed highly significant differences due to genotype for all the characters indicating sufficient genetic variability present in the materials for all the characters. Whereas parents vs hybrids was significant for most of the characters except plant height, siliquae on main

Table 1: Analysis of variance for morphological and quality characters in Indian mustard

Source of sspiation	d.f.	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Branches per plant	Main shoot length (cm)	Siliquae on main shoot	Siliquae per plant	Seed yield (g)	1000-seed weight (g)	Oil content (%)	Erucic acid (%)	Oleic acid (%)	Linolenic acid (%)	Linoleic Acid (%)	Protein content (%)
Replications	2	3.9	13.9*	190.3	11.5	1.0	18.3	1232.6	7.8	0.01	0.31	2.16*	0.12	0.10	0.396	0.016
Genotypes	20	34.3**	44.0**	891.2**	276.6**	180.9**	151.9**	13922.7**	79.7**	1.06**	11.5**	384.92**	216.91**	14.40**	38.98**	3.37**
Parents	5	44.6**	120.6**	1798.6**	129.5**	204.2**	69.3**	17273.9**	153.5**	1.91**	9.4**	1021.91**	535.90**	10.86**	100.33**	8.47**
Hybrids	14	31.3**	10.6**	606.3**	317.2**	170.3**	191.4**	13687.7**	58.8**	079**	12.1**	180.88**	113.11**	13.46**	19.67**	0.61**
P vs. H	1	25.6**	128.9**	343.8	443.4**	212.6**	12.2	511.7	2.6	0.70**	14.6**	56.50**	75.28**	45.35**	2.59*	16.55**
Error	40	1.5	3.8	124.5	6.0	3.69	13.8	897.8	5.2	0.06	0.9	0.60	0.24	0.26	0.21	0.075

*and ** significant at P = 0.05 and P = 0.01 levels, respectively.

Table 2 : Analysis of variance or combining ability, estimates of components of variance and their ratio for various characters in Indian mustard

Source of sspiation	d.f.	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Main branch length (cm)	Siliquae on main branch	Siliquae per plant	Branches per plant	Seed yield (g)	Oil content (%)	Erucic acid (%)	Oleic acid (%)	Linolenic acid (%)	Linoleic Acid (%)	Protein content (%)	1000-seed weight (g)
GCA	5	29.64**	11.28**	756.64**	23.05**	32.13**	4064.61**	38.85**	39.34**	6.66**	472.62**	264.69**	4.23**	27.56**	1.7**	0.47**
SCA	15	5.36**	15.81**	143.89**	72.74**	56.81**	4833.01**	109.98**	22.29**	2.91**	13.53**	8.17**	4.98**	8.13**	0.9**	0.32**
Error	40	0.50	1.27	41.51	1.23	4.59	299.27	2.01	1.74	0.31	0.20	0.08	0.08	0.07	0.0	0.02
s^2gca		3.64	1.25	89.39	2.73	3.44	470.67	4.60	4.70	0.79	59.0	33.07	0.51	3.43	0.21	0.06
s^2sca		4.86	14.54	102.37	71.50	52.22	4533.75	107.97	20.55	2.59	13.33	8.09	4.89	8.06	0.90	0.30
s^2gca/s^2sca		0.75	0.09	0.87	0.04	0.07	0.10	0.04	0.23	0.31	4.42	4.08	0.10	0.42	0.23	0.19

* and ** significant at P = 0.05 and P = 0.01 levels, respectively.

Table 3 : The three top ranking parents with respect to *per se* performance and gca effects; the three top ranking hybrids with respect to *per se* performance and sca effects and heterosis over better parent and check sspiety (GM 2)

Characters	Best performing parents	Best general combiners	Best performing hybrids		Hybrids with high sca effects		sca effects	Heterosis over	
								BP	SC
Seed yield per plant (g)	GM 1	BPR 380-1	RSK 28 x RH(OE)0103	G x P	SKM 532 x GM 3	A x P	9.70**	40.8**	-0.48
	SKM 532	RSK 28	SKM 532 x GM 3	A x P	RSK 28 x RH(OE) 0103	G x P	6.39**	44.76**	32.3**
	BPR 380-1	GM 1	BPR 380-1 x GM 1	G x A	BPR 380-1 x R SK 28	G x G	4.66**	-5.6	-7.37
Days to 50 % flowering	RSK 28	RSK 28	RSK 28 x GM 3	G x P	RSK 28 x GM 3	G x P	-3.87**	-17.42**	-11.71**
	RH(OE)0103	RH(OE) 0103	RSK 28 x RH(OE)0103	G x G	RSK 28 x SKM 532	G x A	-1.37*	-9.09**	-10.35**
	SKM 532	SKM 532	RSK 28 x SKM 532	G x A	BPR 380-1 x GM 1	P x P	-1.35*	1.33	4.84*
Days to maturity	RSK 28	RSK 28	GM 3 x GM 1	A x P	GM 3 x GM 1	A x P	- 2.97**	-4.58**	-4.58**
	GM 3	GM 3	BPR 380-1 x GM 3	A x A	RH(OE)0103 x GM 1	A x P	-2.13*	-3.15*	-3.15*
	SKM 532	BPR 380-1	SKM 532 x GM 3	A x A	BPR 380-1 x GM 3	A x A	-2.11*	-1.47	-4.30**
Plant height (cm)	RH(OE)0103	RH(OE) 0103	RSK 28 x RH(OE)0103	A x G	GM 3 x GM 1	P x P	-15.18*	-14.61**	-3.82
	RSK 28	RSK 28	BPR 380-1 x RH(OE)0103	A x G	RSK 28 x RH(OE)0103	A x G	-9.12	-7.88	-19.81**
	SKM 532	BPR 380-1	RH(OE)0103 x GM 3	G x P	BPR 380-1 x SKM 532	A x A	-4.93	-4.26	-2.46
S iliquae per plant	GM 1	RSK 28	RSK 28 x RH(OE)0103	G x A	RSK 28 x RH(O E)0103	G x A	94.98**	20.24*	1.41
	RSK 28	GM 1	BPR 380-1 x RSK 28	A x G	SKM 532 x GM 3	P x P	84.53**	42.61**	-20.88**
	BPR 380-1	BPR 380-1	BPR 380-1 x RH(OE)0103	A x A	SK M 532 x GM 1	P x G	83.29**	-12.58	-12.41
Oil content (%)	SKM 532	SKM 532	SKM 532 x GM 3	G x P	SKM 532 x GM 3	G x P	2.81**	1.2	5.08*
	RH(OE)0103	BPR 380-1	BPR 380-1 x SKM 532	G x G	BPR 380-1 x GM 3	G x P	1.30*	0.42	-0.98
	GM 1	RH(OE) 0103	BPR 380-1 x RSK 28	G x P	BPR 380-1 x RSK 28	G x P	1.16*	1.32	-0.63
Erucic acid (%)	RH(OE)0103	RH(OE)0103	RSK 28 x RH(OE)0103	P x G	RSK 28 x RH(OE)0103	P x G	-3.65**	-50.68**	-42.44**
	SKM 532	GM 1	RH(OE)0103 x GM 1	G x P	SKM 532 x GM 3	P x P	-1.67**	-10.32**	4.53**
	GM 1	SKM 532	BPR 380-1 x RH(OE)0103	P x A	BPR 380-1 x SKM 532	P x P	-1.54**	-7.78**	3.26*
Oleic acid (%)	RH(OE)0103	RH (OE)0103	RSK 28 x RH(OE)0103	P x G	RSK 28 x RH(OE)0103	P x G	2.34**	-35.08**	136.01**
	SKM 532	SKM 532	RH(OE)0103 x GM 1	G x P	BPR 380-1 x RSK 28	P x P	2.08**	.19.77**	17.24**
	GM 1	RSK 28	RH(OE)0103 x GM 3	G x P	BPR 380-1 x GM 1	P x P	1.28**	3.29	3.29
Linolenic acid (%)	RH(OE)0103	RH (OE)0103	BPR 380-1 x RH(OE)0103	P x G	GM 3 x GM 1	P x G	2.39**	2.25	2.25
	BPR 380-1	GM 1	SKM 532 x GM 1	P x G	SKM 532 x GM 3	P x G	2.22**	-3.69	-6.08
	GM 1	BPR 380-1	RH(OE)0103 x GM 1	G x G	RSK 28 x SKM 532	P x P	1.84**	-8.87**	-10.43**
Linoleic acid	RH(OE)0103	GM 1	RH(OE)0103 x SKM 532	G x A	RSK 28 x SKM 532	G x A	4.68**	22.27**	10.28**

branch, siliquae per plant and seed yield per plant. This indicated existence of considerable amount of genetic variability among parents and hybrids for all the characters in this study, five hybrids showed significant positive relative heterosis. The hybrid RSK 28 x RH (OE) 0103 manifested maximum significant positive relative heterosis (90.0%) and heterobeltiosis (44.8) for seed yield per plant (table 3). In case of number of branches per plant the magnitude of relative heterosis (130.9) and heterobeltiosis (83.3). For siliquae per plant the relative heterosis (49.4) and heterobeltiosis (42.6) were high. For siliquae on main branch, main branch length, 1000 seed weight, plant height and oil content relative heterosis (35.4, 15.4, 19.0, 20.1 and 8.9%), heterobeltiosis (28.3, 10.7, 8.6, 14.1 and -5.3%) and standard heterosis (44.7, 2.7, -2.3, 12.4 and 5.1). Due to short winter in Gujarat, early flowering and maturity is desirable feature in mustard crop. For these characters and plant height, low relative heterosis, heterobeltiosis and standard heterosis was observed in desired direction. Similar results were reported by Tyagi *et al.* (2000), Gupta and Narayan (2005).

The analysis of variance for combining ability (table 2) indicated that the mean squares due to general combining ability and specific combining ability were significant. The variance due to sca was higher than that of due to gca for all the characters. This indicated the role of non-additive gene action in the inheritance of these traits. This is in agreement with the studies of Rao and Gulati (2001) and Patel *et al.* (1993).

The gca, sca ratio ($ó^2_{gca}/ó^2_{sca}$) was less than one for seed yield per plant and it's most of all the characters. This indicated that non-additive components played greater role in the inheritance of these characters. The presence of predominantly large amount of non-additive gene action would be necessitating the maintenance of heterozygosity in the population. Breeding methods such as biparental mating followed by reciprocal recurrent selection may increase frequency of genetic recombination and hasten the rate of genetic improvement.

A close examination of general combining ability effects of the parents revealed that none of the parents was found to be consistently good combiner for all the characters. However, the parent BPR 380-1 was good combiner for seed yield, 1000 seed weight, and oil content. The parent RSK 28 was good combiner for seed yield per plant, days to 50 per cent flowering, days to maturity, branches per plant, siliquae per plant and protein content. The crosses *viz.*, SKM 532 x GM 3, RSK 28 x RH(OE)0103 and BPR 380-1 x RSK 28 which recorded high and significant sca effects for seed yield. There was a close association between *per se* performance of hybrids, heterosis and sca effects and *per se* performance of parents and gca effects. The best three hybrids on the basis of *per se* performance were RSK 28 x RH (OE) 0103, SKM 532 x GM 3 and BPR 380-1 x GM 1. These had also significant sca effects in desired direction and the magnitude of heterosis for seed yield was high and significant.

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