

Original Research Article

<https://doi.org/10.20546/ijcmas.2020.907.083>

Combining Ability and Heterosis for Seed Yield and its Attributing Traits in Indian Mustard (*Brassica juncea* L. Czern & Coss)

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ABSTRACT

Keywords

Grain yield, SCA value, heterosis effect

Article Info

Accepted:
08 June 2020
Available Online:
10 July 2020

Combining ability analysis was done for nine parents including five female lines and four testers male with their twenty crosses. Laxmi and RH – 406 was conferred as the great general combiner distinguished for “grain yield per plant” because of its positive GCA impact. Among the four testers, Varuna, PM – 27 and Pusa Bold were distinguished as great combiner for the same trait and other related characteristics. “Lxmi” was recognized as great general combiner for the greater part of the yield related attributes. C.G.Sarson x Pusa showed the highest SCA value followed by Pusa Agrime x Varuna for “grain yield per plant”. Among the hybrids C.G. Sarson x Kranti and Laxmi x Varuna were reported to be the best for heterosis effect for all characters taken under study.

Introduction

Among the oilseed crops mustard rank second in world with an area of 37.0 mha with a production of 18-50 q per ha. In India the area, production and productivity are 6.3 mha, 7.6 m tones and 11.90 q per ha respectively (Anonymous 2016). Mustard ranks second in area after ground nut and third in production after soybean (Nirajan *et al.*, 2014). Uttar Pradesh, Rajasthan, Madhya Pradesh, Punjab, Haryana, West Bengal, Assam and Bihar are

major mustard growing state in India. In compared to other species of Brassica the crop mustard the crop mustard has higher adaptability in accordance with tolerant to biotic and abiotic stresses (Yadava *et al.*, 2010).

In plant breeding programme, it is essential to select parents with desirable characteristics with good general combining ability (GCA) effects for yield and high estimates of specific combining ability (SCA) effects of hybrids.

A very powerful tool to estimate combining ability effects is Line x Tester analysis introduced by Kempthorne (1957). It imparts information on GCA and SCA effects of parents. It also helps in estimation of various types of gene actions governing the inheritance of characters and thereby, helps to select parents and crosses which are more desirable and superior in performance.

Materials and Methods

Using five lines *viz.* Laxmi, Pusa Agrime, DRMR IJ – 31, C.G.Sarson, RH – 406 as female parents and four testers *viz.* Pusa Bold, Kranti, Varuna and PM – 27 as male parents, twenty crosses were produced through L x T mating design at “Research cum Instructional Farm of S.G. College of Agriculture and Research Station, Kumhrawand, Jagdalpur, Bastar. The crosses were attempted during rabi season 2017-18. The parents and their crosses were evaluated during rabi 2018-19. One checks namely NRCBH – 101 were also planted. maintaining aPlot size – 1.8 x 5 m, Spacing – 30 x 10 cm. Observations were recorded for twelve yield parameters “days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, length of siliqua (cm), length of main raceme (cm), number of siliqua on main raceme, number of seed per siliqua, 1000 seed weight (g), oil content (%) and harvest index (%)”

Results and Discussion

The results of L x T analysis for assessment of combining ability are discussed under the following sub-heads:

ANOVA for line x tester analysis

Table 2 presenting ANOVA for Line x Tester Analysis shows highly significant was observed among treatments for all the

characters under study. The differences were found to be highly significant also for both “parents and hybrids” for all the characters under study.

Combining ability analysis for GCA and SCA effects

Character wise results of combining ability analysis for GCA and SCA effects are briefly described below.

Among the lines, DRMR IJ – 31(-1.067) showed negative highly significant effect. Among the testers, Kranti (-0.033) and Varuna (-0.33) showed negative highly significant GCA effects. The negative GCA effects indicate earliness.

Among the lines, Pusa Agrime (-15.99) and DRMR IJ - 31 showed negative highly significant GCA effect. Among the testers, Pusa Bold showed negative highly significant GCA effects.

GCA effects for primary branches per plant are ranged from -0.13 (Kranti) to 0.33(Varuna). Among the line C.G.Sarson shows negative significant GCA effect where as highly positive GCA effect was observed in Laxmi and Pusa Agrime.

Among the tester Pusa Bold has negatively significant GCA effect whereas Varuna has highly positive GCA effect. Varuna, Laxmi and Pusa Bold were registered the good general combiners for number of primary branches per plant.

GCA effects for secondary branches per plant are ranged from -0.017 (Pusa Agrime) to 0.417(PM - 27). Among the Parents C.G.Sarson, Kranti and Varuna shows negative significant GCA effect where as highly positive GCA effect was observed in Laxmi, PM – 27 and Pusa Bold.

The parents PM – 27 (0.41), Pusa Bold (0.35) and Laxmi (0.31) were registered the good combiners for number of secondary branches per plant. Among the lines, Pusa Agrime (-0.128) showed negative highly significant effect. Among the testers, Varuna (-0.130) showed negative highly significant GCA effects. None of the parents were recorded positive significant for the character length of siliqua.

Both line and tester were found to have highly significant GCA effect. The lines DRMR IJ-31 and C.G. Sarson showed negative highly significant GCA effects where as highly positive GCA effect was observed in RH – 406, Laxmi and Pusa Agrime. Among the tester Pusa Bold and Kranti has negatively significant GCA effect where as Varuna and PM – 27 has highly positive GCA effect. The positive GCA effects indicate their usefulness in breeding for length of main raceme.

Both line and tester were found to have highly significant GCA effect. The lines DRMR IJ-31, Pusa Agrime and C.G. Sarson showed negative highly significant GCA effects where as highly positive GCA effect was observed in RH – 406 and Laxmi.

Among the tester Kranti has negatively significant GCA effect whereas Varuna has highly positive GCA effect. The positive GCA effects indicate their usefulness in breeding for number of siliqua on main raceme. Both line and tester were found to have highly significant GCA effect. The lines C.G. Sarson showed negative significant GCA effects where as highly positive GCA effect was observed in Laxmi. Among the tester Kranti has negatively significant GCA effect whereas no positive GCA effects were reported. The positive GCA effects indicate their usefulness in breeding for number of seeds per siliqua.

Among the line, C.G. Sarson showed positive highly significant GCA effects. Among the testers, Varuna showed positive highly significant GCA effects. Positive effects of parents indicate their usefulness in breeding of developing best hybrids.

Both line and tester were found to have highly significant GCA effect. The lines C.G. Sarson and DRMR IJ – 31 showed negative significant GCA effects where as highly positive GCA effect was observed in Laxmi and pusa Agrime.

Table.1 Details of genotypes used in investigation

Genotypes	Source
Female Parents	
Laxmi	S.G.CARS, Jagdalpur (Bastar),India
Pusa Agrime	IARI, New Delhi, India
C.G.Sarson	S.G.CARS, Jagdalpur (Bastar),India
RH – 406	S.G.CARS, Jagdalpur (Bastar),India
DRMR IJ – 31	S.G.CARS, Jagdalpur (Bastar),India
Male Parents	
Pusa Bold	IARI, New Delhi, India
Kranti	S.G.CARS, Jagdalpur (Bastar),India
Varuna	S.G.CARS, Jagdalpur (Bastar),India
PM – 27	S.G.CARS, Jagdalpur (Bastar),India
Checks	
NRCBH – 101	IGKV, Raipur (C.G.), India

Table.2 Analysis of Variance for L X T

Source of variation	df	Mean Squares						
		Length of	Number of	Number of	1000 seed	Oil	Seed yield	Harvest
		Main	Siliqua on	Seed/siiqua	Weight	Content (%)	Per plant	Index (%)
		Raceme (cm)	Main raceme		(g)		(g)	
Replication	2	4.38	16.63**	5.41**	0.11*	0.79	0.58	5.26
Treatments	28	142.75**	45.97**	2.55**	0.04	4.46**	7.21**	10.61**
Parents	8	82.66**	38.34**	3.00**	0.02	3.73**	3.94**	9.02**
Parents(Lines)	4	63.67**	22.06**	2.26**	0.01	4.00**	3.90**	9.59**
Parents(Testers)	3	129.72**	72.11**	1.22**	0.02	1.62	2.72*	8.53**
Parents(L v/s T)	1	17.46**	2.14	11.26**	0.04	9.04**	7.82**	6.76
Parents v/s Crosses	19	0.81	26.89**	5.52**	0.05	0.059	67.50**	52.63**
Crosses	1	175.52**	50.19**	2.21**	0.05	5.00**	5.41**	9.07**
Line Effect	4	227.30	41.72	2.183	0.08	4.03	9.00	11.08
Tester Effect	3	136.09	27.61	0.733	0.06	4.03	8.90	3.60
Line * Tester Effect	12	168.11**	58.65**	2.59**	0.03	5.56**	3.33**	9.76**
Error	56	2.163	2.16	0.27	0.02	0.77	0.76	1.75
Total	86	47.98	16.76	1.13	0.03	1.97	2.86	4.71

*Significant at p=0.05% level, **Significant at p=0.01% level

Table.3.1 General combining ability effects of parents for different characters

Characters	Days to 50% Flowering	Days to Maturity (cm)	Plant height	Number of Primary Branches/ plant	Number Secondary Branches /plant	Length of siliqua (cm)
Laxmi	0.600	- 0.033	8.778 **	0.300 *	0.317 *	0.047
Pusa Agrim	0.350	-0.533	-15.997 **	0.300 *	-0.017	-0.128 *
C.G. Sarson	-1.067 **	0.217	-6.305 **	-0.200	0.067	-0.020
RH-406	0.767 *	-0.033	6.562 **	-0.617 **	-0.433 **	0.072
DRMR IJ - 31	-0.650	0.383	6.962 **	0.217	0.067	0.030
Pusa Bold	-0.100	-0.550	-6.180 **	-0.400 **	0.350 **	0.057
Kranti	-0.033	0.450	1.020	-0.133	-0.383 **	-0.023
Varuna	-0.300	0.117	1.893 **	0.333 **	-0.383 **	-0.130 *
PM-27	0.433	-0.017	3.267 **	0.200	0.417 **	0.097

*Significant at p=0.05% level, **Significant at p=0.01% level

Table.3.2 General combining ability effects of parents for different characters

Characters	Length of Main Raceme (cm)	Number of Siliqua on Main raceme	Number of Seed/siiqua	1000 seed Weight (g)	Oil Content (%)	Seed Yield/ Plant (g)	Harvest Index (%)
Laxmi	3.075 **	2.017**	0.350 *	0.114 *	-0.390	1.079**	1.290**
Pusa Agrim	1.725 **	-1.400**	0.183	-0.031	0.512	0.704**	-0.058
C.G. Sarson	-2.367 **	-0.900*	0.017	-0.005	-0.269	-0.833**	-0.476
RH-406	-6.450 **	-1.733**	-0.733**	0.038	0.725 **	-0.787 **	0.492
DRMR IJ - 31	4.017 **	2.017 **	0.183	-0.117 *	-0.578 *	-0.163	- 1.24**
Pusa Bold	-0.843 *	-0.183	0.033	-0.035	0.038	-0.296	0.654
Kranti	-3.903 **	-1.783**	-0.300*	-0.073	-0.442	-0.728 **	-0.190
Varuna	2.430 **	1.417 **	0.033	0.068	0.716 **	-0.055	0.040
PM-27	2.317 **	0.550	0.233	0.041	-0.312	1.078 **	-0.504

*Significant at p=0.05% level, **Significant at p=0.01% level

Table.4.1 Specific combining ability effects of hybrids for different characters

	Days to 50%	Days to	Plant	Number of	Number of	Length of
Characters	Flowering	maturity	height	Primary	Secondary	siliqua
			(cm)	Branches/ plant	Branches /plant	(cm)
Laxmi x Pusa Bold	-2.40**	0.30	5.22**	-0.43	-0.18	-0.20
Laxmi x Kranti	0.86	0.63	7.82**	0.63*	-0.11	0.24
Laxmi x Varuna	1.13	0.63	1.81	0.16	0.88**	-0.05
Laxmi x PM - 27	0.40	-1.56	-14.85**	-0.36	-0.58 *	0.02
Pusa Agrim x Pusa Bold	1.18	0.13	5.09 **	-0.10	-0.51*	0.10
Pusa Agrim x Kranti	0.11	1.46	- 22.17**	-0.70*	-0.45	-0.31*
Pusa Agrim x Varuna	0.38	-1.53	7.85**	0.50	0.55*	0.18
Pusa Agrim x PM -27	-1.68*	-0.06	9.21**	0.30	0.41	0.02
C.G. Sarson x Pusa Bold	1.26	0.71	-11.06**	0.06	0.40	-0.10
C.G. Sarson x Kranti	-1.46*	-0.28	9.07**	-0.53	0.13	0.007
C.G. Sarson x Varuna	-1.20	0.38	-17.06**	-0.33	-0.53*	0.04
C.G. Sarson x PM - 27	1.400*	-0.81	19.05**	0.80**	0.32	0.05
RH – 406 X Pusa Bold	-1.56*	0.63	14.67**	0.15	0.23	0.10
RH – 406 X Kranti	1.03	-1.36	-2.26	-0.11	-0.36	0.14
RH – 406 X Varuna	0.30	-0.36	-9.33**	0.08	-0.36	-0.14
RH – 406 X PM - 27	0.23	1.10	-3.07*	-0.11	0.50	-0.10
DRMR IJ – 31 X Pusa Bold	1.517*	-1.78	-13.92**	0.31	0.06	0.11
DRMR IJ – 31 X Kranti	-0.55	-0.45	7.53**	0.71*	0.80**	-0.07
DRMR IJ – 31 X Varuna	-0.61	0.88	16.73**	-0.41	-0.53*	-0.03
DRMR IJ – 31 X PM - 27	-0.35	1.35	-10.34**	-0.61*	-0.33	0.003

*Significant at p=0.05% level, **Significant at p=0.01% level

Table.4.2 Specific combining ability effects of hybrids for different characters

Characters	Main raceme	Silique on	Seed/siigua	Weight	Content	Yield/ plant	Index (%)
Laxmi x Pusa Bold	-2.15*	0.38	-0.002	0.30	0.39	1.72*	-2.15*
Laxmi x Kranti	3.11**	0.71*	-0.17	-1.46**	0.62	-2.04*	3.11**
Laxmi x Varuna	5.25**	-0.28	0.17	2.41**	1.35*	-0.58	5.25**
Laxmi x PM - 27	-6.21**	-0.81**	0.008	-1.25*	-2.37**	0.90	-6.21**
Pusa Agrim x Pusa Bold	-4.40**	0.21	0.02	-1.33*	-0.86	1.03	-4.40**
Pusa Agrim x Kranti	-0.46	-0.45	0.05	1.57**	-0.30	-1.90*	-0.46
Pusa Agrim x Varuna	3.00**	-0.45	-0.04	-1.13*	0.04	-0.88	3.00**
Pusa Agrim x PM -27	1.86*	0.68*	-0.03	0.89	1.13*	1.75*	1.86*
C.G. Sarson x Pusa Bold	2.10*	1.05**	0.12	-0.15	0.81	-2.08**	2.10*
C.G. Sarson x Kranti	-1.30	-0.61*	-0.05	0.02	-0.36	1.58*	-1.30
C.G. Sarson x Varuna	-6.50**	0.05	-0.006	-1.23*	-0.87	0.86	-6.50**
C.G. Sarson x PM - 27	5.70**	-0.48	-0.06	1.37*	0.42	-0.37	5.70**
RH – 406 X Pusa Bold	3.26**	- 0.86**	-0.02	0.85	0.30	-2.02*	3.26**
RH – 406 X Kranti	1.86*	0.80*	0.09	-0.28	-0.39	2.25**	1.86*
RH – 406 X Varuna	-2.66**	-0.86**	-0.02	-0.62	-0.14	0.85	-2.66**
RH – 406 X PM - 27	-2.46**	0.93 **	-0.04	0.05	0.23	-1.08	-2.46**
DRMR IJ – 31 X Pusa Bold	1.18	-0.78*	-0.12	0.33	-0.65	1.34	1.18
DRMR IJ – 31 X Kranti	-3.217**	-0.45	0.07	0.15	0.44	0.10	-3.217 **
DRMR IJ – 31 X Varuna	0.91	1.55**	-0.09	0.57	-0.37	-0.24	0.91
DRMR IJ – 31 X PM - 27	1.11	-0.31	0.13	-1.07*	0.58	-1.20	1.11

*Significant at p=0.05% level, **Significant at p=0.01% level

Among the testers Kranti has negatively significant GCA effect whereas PM – 27 has positive GCA effects were reported. The positive GCA effects indicate their usefulness in breeding for seed yield per plant. Both line and tester were found to have highly significant GCA effect. The lines C.G. Sarson showed negative significant GCA effects where as highly positive GCA effect was observed in Laxmi. Among the testers no significant GCA effect where reported. The positive GCA effects indicate their usefulness in breeding for harvest index. Among lines, positive significant GCA value for Laxmi(1.07) and Pusa Agrime (0.7) for seed yield per plant makes them good general combiners. Among the testers, PM – 27 (1.07) were found to be good combiners for the same trait. The hybrids, C.G. Sarson x Pusa Bold (1.35) showed the highest SCA value followed by C.G. Sarson x Kranti (1.13) for “seed yield per plant.”

High PCV (Phenotypic coefficient of variation) and GCV (Genotypic coefficient of variation) were observed in seed yield per plant (g) followed by number of secondary branches per plant. The highest heritability were observed for the character plant height followed by length of main raceme (cm) and seed yield per plant (g). High genetic advance as percent of mean was reported for the seed yield per plant (g) followed by length of main raceme (cm). Higher PCV coupled with high GCV, heritability and genetic advance as percent of mean were reported character seed yield per plant (g). Days to 50% flowering showed positive correlation with primary

branches per plant, length of siliqua, length of main raceme and harvest index. The maximum direct effect towards seed yield (g) were reported in number of secondary branches per plant followed by number of seed per siliqua, number of primary branches per plant, test weight and plant height. Parent Laxmi is found to be the best general combiner followed by Varuna, RH – 406, C.G. Sarson, PM – 27 and Pusa Bold where as the best specific combiner among the twenty hybrids are C.G.Sarson x Pusa Bold and Pusa Agrime x Varuna for different characters. Among the hybrids C.G.Sarson x Kranti and Laxmi x Varuna were reported to be the best for heterosis effect for all characters taken under study.

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How to cite this article:

Ashish Sahu, J. L. Salam, Surbhi Verma and Stanley Samuel. 2020. Combining Ability and Heterosis for Seed Yield and its Attributing Traits in Indian Mustard (*Brassica juncea* L. Czern & Coss). *Int.J.Curr.Microbiol.App.Sci*. 9(07): 720-727.
doi: <https://doi.org/10.20546/ijcmas.2020.907.083>