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Combining ability analysis for seed yield and its attributes in Indian mustard [*Brassica juncea* (L.) Czern and Coss]

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ABSTRACT

The experimental material comprised of forty eight genotypes consisting of five Mori based CMS lines and seven Mori based fertile lines crossed in line x tester mating design. The resultant thirty five hybrids along with their twelve parents and standard check (GDM 4) were evaluated in randomized block design at Castor-Mustard Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during, rabi 2018-2019. The analysis of variance for combining ability revealed that variance due to gca was significant for all the characters except number of seeds per siliqua, seed yield per plant and 1000 seed weight. Whereas, variance due to sca was significant for all the traits. This indicates significant contribution of hybrids for specific combining ability variance component. The ratio of σ^2gca/σ^2sca below than unity for days to maturity, siliqua length, number of seeds per siliqua, seed yield per plant, 1000 seed weight and oil content which suggested greater role of non-additive gene action in the inheritance of these traits. Among the parents, female SKM 9928 and Kranti were good general combiner for seed yield per plant, total number of branches per plant and total number of siliquae per plant. Whereas, male parent Mori 'R' 1-18 was good general combiner for seed yield per plant, total number of branches per plant and total number of siliquae per plant. Best three hybrids which possessed significant positive SCA effects for seed yield per plant were SKM 301 x SKM 303, SKM 9928 x Pusa Agrani and Kranti x Mori 'R' 1-18.

Keywords: Line x Tester, Combining ability, gene action, Indian mustard

INTRODUCTION

Indian mustard belongs to family *Brassicacae* and genus *Brassica*, popularly known as rai or raya. Indian mustard or brown mustard [*Brassica juncea* (L.) Czern &Coss] is a natural amphidiploid (2n = 36) of *Brassica rapa* (2n = 20) and *Brassica nigra* (2n = 16). Mustard is largely self pollinated but certain amount (<18.7%) of cross pollination may take place. Indian mustard is mainly used for extraction of oil. Seed of Indian mustard contain 38 to 40 per cent oil and is mainly utilized for human consumption throughout Northern India for cooking as well as frying purpose. Besides, its oil also serves as an important raw material for industrial products like soap, paints, lubricants etc. Its oil cake is rich in protein but due to its high glucosinolate content it is not suitable for animal feed. Combining ability analysis is one of the powerful tools to test the value of parental lines to produce superior hybrids and valuable recombinants (Singh *et al.*, 2013). Further, for developing better genotypes through hybridization, the choice of suitable parents is of great concern. The concept of combining ability was developed by Sprague and Tatum (1942). According to them, general combining ability (GCA) measures the average performance of a line in cross combinations while specific combining ability (SCA) measures the deviation of certain expected combinations on the basis of average performance of the lines involved. The combining ability analyses also provide information about the nature and magnitude of gene action involved in the expression of various quantitative characters. Keeping all this in view, the present investigation on combining ability analysis for seed yield and its attributes in Indian mustard [*Brassica juncea* (L.) Czern & Coss] was undertaken with the objective to estimate the general and specific combining ability effects and variances.

MATERIALS AND METHODS

The experimental material for the present investigation consisted of five *Mori* based CMS lines as female parent (SKM 301, SKM 9928, GM 1, Kranti and GM 2) and seven *Mori* based restorer lines as male parent (Vardan, Rohini, SKM 319, SKM 303, Pusa Agrani, PCR 7 and

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Mori 'R' 1-18). Five lines were crossed with seven testers in line x tester mating design during *rabi* 2017-18 to obtain 35 F_1 hybrids of Indian mustard. At the same time, male sterile lines (A lines) were crossed with its maintainer lines (B line) to get seeds of female parents for evaluation in the next season and the testers or restorer lines (male parents) were selfed to get pure seeds. Female line is CMS, so hand emasculation is not necessary while hybridization was carried out by manual hand pollination. During *rabi* 2018-19, a set of 48 genotypes comprising of twelve parents and their 35 F_1 hybrids along with standard check GDM 4 were sown in randomized block design with three replications at Castor-Mustard Research Station, S. D. Agricultural University, Sardarkrushinagar. Sardarkrushinagar is situated at semi-arid region of North Gujarat. Geographically, it is situated at 24°.31' N latitude and 72°.32' E longitude with an altitude of 154.52 meters above the mean sea level. The soil of the experimental field was sandy loam with pH 7.5. Each treatment was planted in one row, of 3 m length and 45 cm apart, plant to plant distance was maintained 15 cm by thinning. The recommended agronomical practices and plant protection measures were adopted as per requirement. The observations were recorded on five randomly selected plants from each replication for all the traits *viz*., plant height (cm), total number of branches per plant, total number of siliquae per plant, length of siliqua (cm), number of seeds per siliqua, seed yield per plant (g), 1000 seed weight (g) and oil content (%) except days to flowering and days to maturity which were recorded on plot basis. Final mean data pertaining to various characters were analyzed as per the procedure of RBD. The combining ability analysis was performed for a Line x Tester mating design as per the method suggested by Kempthorne (1957). The oil content of each samples were estimated in percentage by using Nuclear Magnetic Resonance (NMR) Technique (Tiwari *et al.* 1974).

RESULTS AND DISCUSSION

The analysis of variance for combining ability revealed that the mean square due to females (lines) was significant for all the characters under study except number of seeds per siliqua, seed yield per plant, 1000 seed weight and oil content (Table 1).

Table 1: Analysis of variance (Mean sum of square) for combining ability and estimates of components of variance for ten characters in Indian mustard

Source of variation	d.f	Days to flowering	Days to maturity	Plant height	Total number of branches per plant	Total number of siliquae per plant	Siliqua length	Number of seeds per siliqua	Seed yield per plant	1000 seed weight	Oil content
Replications	2	2.12	7.80	186.20	1.30	373.92	0.02	1.12	0.28	0.02	0.07
Crosses	19	19.72**	10.30**	648.65**	61.56**	13518.69**	1.05**	6.46**	114.89**	1.22**	1.40**
Females	4	51.85**	25.27*	1623.06**	93.61*	20186.27*	2.70*	10.08	49.15	1.72	2.99
Males	3	30.64*	7.57	794.59	157.65*	34916.39*	0.52	4.77	190.48	0.30	0.48
Females x males	12	6.28*	5.99*	287.36	26.85**	5946.74**	0.79**	5.68**	121.87**	1.29**	1.09**
Error	38	2.36	2.48	181.81	3.65	1031.90	0.05	0.75	11.18	0.02	0.14
σ^2 Females		4.13**	1.88*	122.50**	7.55*	1606.17*	0.22*	0.74	4.01	0.14	0.24
σ^2 Males		1.89*	0.32	42.77	10.31*	2266.95*	0.03	0.24	10.08	0.02	0.02
σ^2 gca		2.89**	1.01**	78.21**	9.08**	1973.27**	0.12*	0.46	7.91	0.07	0.12*
σ^2 sca		1.34**	1.09*	44.78	7.94**	1678.20**	0.25**	1.48**	56.44**	0.42*	0.32**
σ^2gca/σ^2sca		2.16	0.93	1.75	1.14	1.18	0.48	0.31	0.14	0.17	0.38

** P ≤ 0.05, ** P ≤ 0.01*

This indicated significant contribution of females towards general combining ability variance component for these traits. The variance due to males (tester) was significant for the days to flowering, total number of branches per plant and total number of siliquae per plant. The line x tester interaction was significant for all the characters except plant height. This indicates

significant contribution of hybrids for specific combining ability variance component. The variance component due to females was higher than that of males for days to flowering, days to maturity, plant height, siliqua length, number of seeds per siliqua, 1000 seed weight and oil content. The ratio of σ^2gca/σ^2sca below than unity for days to maturity, siliqua length, number of seeds per siliqua, seed yield per plant, 1000 seed weight and oil content which suggested greater role of non-additive gene action in the inheritance of these traits. The presence of predominantly large amount of non-additive gene action it must be required to maintain heterozygosity in the population. These results are in accordance with the findings of Meena *et al.* (2017), Rashmi *et al.* (2018) and Thanmichon *et al.* (2018). Whereas, the ratio of σ^2gca/σ^2sca found more than unity for days to flowering, plant height, total number of branches per plant and total number of siliquae per plant which suggested greater role of additive gene action in the inheritance of these traits. The above results are in agreement with the results of Kumar *et al.* (2017), Dahiya *et al.* (2018) and Shrimali *et al.* (2018).

General combining ability

The perusal of data (Table 2) revealed that none of the parents was identified good general combiner for all the characters under study. Among the parents, line SKM 9928 was good general combiner for seed yield per plant, total number of branches per plant, siliqua length, number of seeds per siliqua and total number of siliquae per plant; Kranti was good general combiner for total number of branches per plant, total number of siliquae per plant, seed yield per plant and 1000 seed weight, while GM 2 was good general combiner for days to flowering, days to maturity, plant height and oil content. Whereas tester Mori 'R' 1-18 was good general combiner for seed yield per plant, total number of branches per plant and total number of siliquae per plant. Present results are in concurrence with those of Meena *et al.* (2015).

Table 2: Estimation of general combining ability (GCA) effects of parents for various characters in Indian mustard

	Parents	Days to flowering	Days to maturity	Plant height	Branches per plant	Siliquae per plant	Siliqua length	Seeds per siliqua	Seed yield pe plant	1000 seed weight	Oil content
Lines	SKM 301	0.483	0.400	11.517**	-0.240	-11.620	0.229**	0.513	-2.250*	-0.496**	-0.104
	SKM 9928	3.150**	1.567**	5.517	3.993**	52.797**	0.709**	1.330**	5.049**	-0.244**	0.132
	GM 1	-1.267**	-0.767	6.600	-3.557**	-57.037**	-0.401**	-0.803*	-4.212**	0.284**	-0.510**
	Kranti	-0.017	0.900	-6.567	1.027*	22.547*	-0.125*	-0.253	3.140**	0.431**	-0.303**
	GM 2	-2.350**	-2.100**	-17.067**	-1.223*	-6.687	-0.411**	-0.787*	-1.728	0.026	0.786**
	S.Em. ±	0.433	0.477	3.571	0.503	8.719	0.058	0.320	0.861	0.039	0.107
Testers	SKM 303	1.700**	0.917*	2.550	-3.310**	-45.683**	0.136*	0.130	-3.449**	-0.147**	0.261**
	Pusa Agrani	0.500	-0.017	7.750*	-1.283**	-22.923**	0.165**	0.383	-0.878	0.014	-0.025
	PCR 7	-0.567	-0.083	-9.583**	0.250	2.543	-0.234**	-0.830**	-0.653	0.186**	-0.127
	Mori 'R' 1-18	-1.633**	-0.817	-0.717	4.343**	66.063**	-0.067	0.317	4.979**	-0.053	-0.109
	S.Em. ±	0.387	0.427	3.194	0.450	7.798	0.052	0.286	0.770	0.035	0.095

** P ≤ 0.05, ** P ≤ 0.01*

Specific combining ability

Out of thirty five crosses, fifteen crosses were sterile in both the study, pollen fertility (0%) and siliquae set per cent (0%) so, these fifteen sterile crosses were not considered for the estimation combining ability. The specific combining ability effects of crosses are presented in Table 3. Based on high SCA effect hybrids SKM 301 x SKM 303, SKM 9928 x Pusa Agrani and Kranti x Mori 'R' 1-18 were identified as best specific cross combination for seed yield per plant. Thus, they were good hybrid combinations, contributing towards higher seed yield. The cross SKM 301 x SKM 303 (-2.333) exhibited significant negative SCA effect for days to maturity. The hybrids *viz.,* SKM 9928 x Pusa Agrani (4.633), GM 2 x Mori 'R' 1-18 (3.290),

SKM 301 x PCR 7 (2.800) and Kranti x SKM 303 (2.693) were good specific combiners for total number of branches per plant and total number of siliquae per plant. Therefore, considered as good specific combiners for total number of branches and siliquae per plant. The six hybrids namely, SKM 9928 x SKM 303 (0.639), GM 2 x Pusa Agrani (0.623), SKM 9928 x Pusa Agrani (0.397), GM 1 x PCR 7 (0.392), Kranti x PCR 7 (0.349) and SKM 301 x Mori 'R' 1-18 (0.289) were exhibited significant positive SCA effects for siliqua length therefore, they were good hybrid combinations contributing towards more siliqua length. The three hybrids *i.e.,* SKM 301 x Mori 'R' 1-18 (1.767), GM 2 x Pusa Agrani (1.533) and SKM 9928 x SKM 303 (1.403) were recorded significant positive SCA effects for number of seeds per siliqua. Thus, these three hybrids were considered as good specific combiners for contributing towards more number of seeds per siliqua.

Table 3: The estimates of specific combining ability (SCA) effects for various characters in Indian mustard

Crosses	Days to flowering	Days to maturity	Plant height	Branches per plant	Siliquae per plant	Siliqua length	Seeds per siliqua	Seed yield per plant	1000 seed weight	Oil content
SKM 301 x SKM 303	-1.283	-2.333*	8.950	0.960	5.900	0.219	1.087	7.165**	1.219**	-0.097
SKM 301x Pusa Agrani	0.917	1.600	4.750	-2.933**	-28.927	-0.517**	1.833**	-7.816**	-0.863**	0.262
SKM 301 x PCR 7	-0.683	0.667	-7.583	2.800**	39.607*	0.009	-1.020	1.166	0.022	0.298
SKM 301x Mori R' 1-18	1.050	0.067	-6.117	0.827	-16.580	0.289*	1.767**	-0.515	-0.379**	-0.464*
SKM 9928 x SKM 303	0.717	-0.500	-2.383	-3.140**	-46.450*	0.639**	1.403*	-0.531	0.160*	0.214
SKM 9928xPusa Agrani	0.917	-0.233	3.417	4.633**	73.923**	0.397**	-0.250	4.739**	-0.032	0.017
SKM 9928 x PCR 7	-0.683	0.500	-3.250	1.367	15.923	-0.925**	-1.370*	-1.273	0.093	-0.331
SKM 9928xMori 'R' 1-18	-0.950	0.233	2.217	-2.860**	-43.397*	-0.111	0.217	-2.935	-0.221**	0.101
GM 1 x SKM 303	0.800	1.167	7.867	1.543	27.383	-0.051	-0.397	-3.123	-1.221**	0.685**
GM 1 x Pusa Agrani	-0.333	-1.233	-4.667	0.317	-4.710	-0.287*	0.283	2.500	0.778**	-0.775**
GM 1 x PCR 7	-0.267	-0.833	-1.333	-0.217	4.223	0.392**	1.097	2.954	0.146	-0.346
GM 1 x Mori 'R' 1-18	-0.200	0.900	-1.867	-1.643	-26.897	-0.055	-0.983	-2.331	0.298**	0.436*
Kranti x SKM 303	2.217*	2.167*	-0.633	2.693*	36.800*	-0.107	-0.147	0.315	-0.388**	-0.394
Kranti x Pusa Agrani	-1.917*	-1.567	8.500	-2.800**	-47.427**	-0.217	0.267	-1.849	0.321**	0.172
Kranti x PCR 7	0.150	0.167	-5.833	-1.933	-29.160	0.349**	0.480	-2.271	-0.238**	0.914**
Kranti x Mori 'R' 1-18	-0.450	-0.767	-2.033	2.040*	39.787*	-0.025	-0.600	3.805*	0.305**	-0.691**
GM 2 x SKM 303	-2.450**	-0.500	13.800	-2.057*	-23.633	0.701**	1.947**	-3.827*	0.231**	-0.408
GM 2 x Pusa Agrani	0.417	1.433	12.000	0.783	7.140	0.623**	1.533*	2.426	-0.204*	0.325
GM 2 x PCR 7	1.483	-0.500	18.000*	-2.017	-30.593	0.175	0.813	-0.576	-0.023	-0.536*
GM 2 x Mori 'R' 1-18	0.550	-0.433	7.800	3.290**	47.087*	-0.098	-0.400	1.976	-0.004	0.619**
S.Em. ±	0.866	0.954	7.142	1.006	17.437	0.115	0.640	1.722	0.0784	0.213

** P ≤ 0.05, ** P ≤ 0.01*

The seven crosses *viz.,* SKM 301 x SKM 303 (1.219), GM 1 x Pusa Agrani (0.778), Kranti x Pusa Agrani (0.321), Kranti x Mori 'R' 1-18 (0.305), GM 1 x Mori 'R' 1-18 (0.298), GM 2 x SKM 303 (0.231) and SKM 9928 x SKM 303 (0.160) recorded significant and positive SCA effects for 1000 seed weight. Hence, these hybrids were considered for bolder seed size. Out of twenty hybrids, four hybrids such as Kranti x PCR 7 (0.914), GM 1 x SKM 303 (0.685), GM 2 x Mori 'R' 1-18 (0.619) and GM 1 x Mori 'R' 1-18 (0.436) exhibited significant positive SCA effects for oil content. Thus, these hybrids were considered as good specific combiners for oil content. The similar results were also reported by Patel *et al.* (2013), Meena *et al.* (2015) and Gideon *et al.* (2015).

Based on above result it can be concluded that line SKM 9928 was good general combiner for seed yield per plant, total number of branches per plant, siliqua length, number of seeds per siliqua and total number of siliquae per plant and another line Kranti was good general combiner for total number of branches per plant, total number of siliquae per plant, seed yield per plant and 1000 seed weight. Whereas tester Mori 'R' 1-18 was good general combiner for seed yield per plant, total number of

branches per plant and total number of siliquae per plant. It suggested that these parents might be presumed to be relatively greater number of favorable alleles for developing superior hybrids or varieties of Indian mustard. Based on high SCA effect, hybrids SKM 301 x SKM 303 (P x P), SKM 9928 x Pusa Agrani (G x P) and Kranti x Mori 'R' 1-18 (G x G) were identified as best specific cross combination for seed yield per plant. These hybrids need to be tested in multilocation trials for stability analysis.

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