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RESEARCH ARTICLE

Estimates of combining ability, yield and yield components in Indian mustard (*Brassica juncea* L.)

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SUMMARY

Combining ability analysis of 10×10 diallel set of crosses in Indian mustard for ten quantative traits revealed preponderance of non-additive gene effects for plant height, number of primary branches per plant and seed yield per plant, whereas additive gene effect was found to be predominant for the inheritance of rest of the character. The parent Varuna, RH-3904 and RH-819 were the good general combiners for seed yield and oil content. Varuna and RH-819 also exhibited desirable general combining ability effect for earliness and dwarfness. Among the cross combination, cross Varuna×RH-819 exhibited superior specific combiningability effect for days to 50% flowering, number of secondary branches per plant and other yield attributing traits. Most of the cross involving high-low general combining parent, exhibited high sca effect for various traits. Seed yield was highly, significantly and positively correlated with days to 50 % flowering, plant height, number of primary branches per plant, length of siliqua, and test weight. Hence, selection for the higher values of these traits will be desirable to increase seed yield.

Key Words : *Brassica juncea*, General combining ability, Specific combining ability, Correlation, Seed yield

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Mustard is the premier winter edible oilseed crop in India. It is second most important edible oilseed crop of the India after groundnut. Mustard seed contains about 38 to 43 per cent oil which is yellow fragment and is considered to be the healthiest and nutritious cooking medium. It is a plant of Asiatic origin with major center of diversity in china and it was introduced in India from China. Indian mustard [*Brassica juncea* (L.) Czern & Coss] is a natural amphidiploids (2n=36) of Brassica campestris (2n=2) and Brassica nigra (2n=16). It is (85 to 90 %) self pollinated crop and 4 to 15% cross pollinated by honey bees. Indian mustard [*Brassica juncea* (L.) Czern & Coss] is an important oilseed crop of the world. The average contribution of rapeseed mustard to the total oilseed production in India was 24.2% during 2012 – 2013.The average productivity was 1176 kg/ha of total oilseeds [Directorate of

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Rapeseed- Mustard Research, (Indian council of Agricultural Research) Sewar, Bhagalpur 321303].It plays a major role in catering edible oil demand of the county. Population of India is increasing rapidly and consequently edible oil demand is also going up day- by-day. Hence, it has become necessary to enhance the present production by developing superior varieties of Indian mustard. The development of superior variety could be done by reshuffling the genes through hybridization from suitable parents. Moreover, it is also necessary to know about the nature and magnitude of gene action responsible for controlling the inheritance of various yield attributes along with combining ability of the parent and their cross combination in order exploit them in further crop improvement programme. Many authors applied different strategies for improving seed yield and quality attributed of Brassica (Singh, 2003 and Singh *et al*., 2009). Various workers have reported difference types of gene action and combining abilities in different sets of material studies. The ample analysis of the combining ability involved in the inheritance of quantitative characters. Combining ability studies highlighted the predominance effects of GCA on yield and most of the yield components indicating the important of additive gene action (Wos *et al*., 1999). While Pandey *et al*. (1999) review evidence for the presence of significant SCA effects for yield and yield components indicating importance of non- additive gene action. As known seed yield is a complex character that can be determined by several components. In order to attract the attention to which one has greatest influence on seed yield. Correlations between yield and yield components have repeatedly been analyzed in traditional cultivars of mustard with high oil per cent.

MATERIAL AND METHODS

Ten parents *viz.*, Varuna, Rohini, Krishna, Vaibhav, Vardan, Maya, NDRE-4, RH-9304, RH-819, and Pusa Mahak were crossed in half diallel fashion to produce 45 F_1s. Ten parents and their 45F_1s were grown in a Randomized Block Design with three replications. Each parent and F_1s were grown in single row of 5m length with row to row and plant to plant distance of 45 and 15cm, respectively in each replication during *Rabi* (post rainy) 2010-2011 at the experimental research farm of Tilakdhari Post Graduate College, Jaunpur (Uttar Pradesh). Recommended cultural practices were adopted in order to raise a healthy crop. A sample of five representative plants were taken from each plot for recording data on plant height number of primary branches, number of secondary branches,number of siliquae on main raceme, seed yield, 1000- seed weight and oil content in each replication while data on days 50% flowering, days to maturity were recorded on plot basis. Mean values of sample for various traits were subjected to combining ability analysis method II model I of Griffing (1956) and correlation co-efficient analysis was used as suggested by Robinson *et al*. (1951).

RESULTS AND DISCUSSION

The analysis of variance revealed considerable genetic diversity among the parent, cross combination as well as between parent group and cross combinationgroup for all the characters. Analysis combining ability (Table 1) indicated that mean sum of square due to the both general and specific combining ability were significant for all the characters except length of siliqua, 1000 seed weight and seed yield suggesting importance of both additive and non-additive gene effect in the inheritance of these character. Similar findings were observed by earlier workers (Singh *et al*., 2008; Singh and Dixit, 2006; Singh *et al*., 2006; Srivastava *et al*., 2009 and Yadav *et al*., 2005). Relative magnitude of non-additive gene effect was predominant in controlling the inheritance of plant height, number of primary branches and seed yield per plant, whereas additive gene effect were found predominant for controlling the inheritance of rest of the other characters. A persusal of general combining ability (GCA) effect of parent indicated that none of the parent was found to be

Table 1 : Analysis of variance for combining ability for ten characters in Indian mustard

Source	D.F.	Days to 50% flowering	Days to Maturity	Plant height (cm.)	No. of primary branches/ plant	No. of secondary branches/ plant	No. of siliquae on main raceme	Length of siliqua (cm)	No. of seeds/ siliqua	1000 seed weight (g)	Seed yield per plant (g)	Oil content
GCA	9	6.784**	152.168**	267.243**	6.582**	44.861**	93.225**	0.109**	3.697**	0.280**	0.758*	21.089**
SCA	45	17.412**	59.256**	474.9019**	2.815**	72.599**	96.461**	0.223	2.763**	0.295	1.004	83.978**
Error	108	0.793	1.874	13.952	0.280**	1.023	1.287	0.023	0.244	0.028	0.332	0.759

Note : *and ** indicate significance of values at P=0.05 and 0.01, respectively

good general combiner for all the traits (Table 2). Parents Varuna (length of siliqua) Rohini (day to maturity, plant height), Krishna (days to maturity) Varuna (days to 50% flowering) RH-9304 (days to 50% flowering) Pusa Mahak (plant height) can be calculated parent Vaibhav, NDRE-4, RH-819, Pusa Mahak, possess desirable allele for most of the characters. Here these parents could be used in future for improvement of respective character.

The results of the correlation co-efficient among the traits studies during 2010-11 are shown in Table 4. A high positive and significant correlation (P<0.01) was observed between length of siliqua (0.320), test weight (0.358), oil content (0.580) and days to 50% flowering; number of primary branch per plant (0.291), oil content

Table 2: Estimate of GCA effects of different character in 10- parent diallele cross in *Brassica juncea* F_1

Sr. No.	Parent	Days to 50% flowering	Days to maturity	Plant height (cm.)	No. of primary branches / plant	No. of secondary branches/ plant	No. of siliquae on main raceme	Length of siliqua (cm.)	No. of seeds/ siliqua	1000 seed weight (g)	Seed yield per plant (g)	Oil content
1.	Varuna	-1.39**	-2.04**	1.41	0.42**	3.01**	5.80**	0.00	-092**	-0.29**	0.09**	-0.71**
2.	Rohini	-0.62**	-0.23	1.13	-0.78**	-0.91**	1.08**	-0.01**	-044**	-0.15**	-0.13**	-2.48**
3.	Krishna	-0.45**	1.49	3.99*	-0.78**	-1.27**	2.30**	0.03**	0.17**	-0.01**	-0.09**	-0.45**
4.	Vaibhav	-0.48**	2.52**	9.38**	1.28**	-1.63**	-3.31**	0.17**	0.14**	0.06**	0.46**	-1.62**
5.	Vardan	-0.09	4.63**	2.58**	0.08**	-0.22**	1.99**	-0.14**	0.19**	-0.10**	-0.02	1.51**
6.	Maya	0.61**	4.52**	-1.28	0.97**	0.64**	-1.62**	-0.11**	0.42**	0.10**	-0.33**	0.22**
7.	NDRE-4	0.91**	1.82**	-4.14**	-0.75**	1.17**	-1.95**	0.10**	0.92**	0.18**	-0.11**	0.75**
8.	RH-9304	0.02	-3.01**	-5.09**	-0.50	-2.11**	-2.67**	0.01**	-0.56	0.08**	0.39**	0.73**
9.	RH-819	0.66**	-5.18**	-6.20	-0.25**	3.14**	-0.73**	0.04**	0.56	0.12**	-0.06**	1.65**
10.	Pusa Mahak	0.83**	-4.51**	-1.78	0.31**	-1.83**	-0.89**	-0.09**	-0.14	0.17**	-0.20**	0.41**
	SE (gi)	0.059	0.140	1.046	0.021	0.076	0.096	0.001	0.018	0.002	0.024	0.056
	SE (gi-gj)	0.132	0.312	2.325	0.046	0.170	0.214	0.003	0.040	0.004	0.055	0.126

Note: * and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Estimates of SCA effects of top three combinations for ten characters in Indian mustard

Cross combination	Specific combining ability effects		
Days to 50% flowering		Varuna x NDRE	13.93**
Varuna x RH-819	-5.12**	Rohini x Krishna	24.74**
Maya x NDRE-4	-4.37**	**Length of siliqua**	
Varuna x Vardan	-3.70**	Varuna x Pusa Mahak	0.47
Days to maturity		Rohini x Krishna	-0.84
Rohini x Vardan	-15.98**	Vaibhav x RH-819	0.73
Krishna x Pusa Mahak	-10.90**	**Number of seeds/ Siliqua**	
Vaibhav x NDRE-4	-10.26**	Rohini x Krishna	-3.03**
Plant height		NDRE-4 x RH-9304	3.00**
Vaibhav x RH-9304	25.79*	NDRE-4 x RH-819	-2.44**
Maya x Pusa Mahak	-32.52**	**1000 Seed weight (g)**	
Maya x RH-9304	27.79*	Varuna x Krishna	-1.10**
Number of primary branches/plant		Rohini x Krishna	0.75**
Rohini x Vaibhav	3.32**	Rohini x Vardan	-1.18**
Vaibhav x Vardan	3.46**	**Seed yield per plant (g)**	
RH-819 x Pusa Mahak	3.43**	Krishna x Vaibhav	3.14**
Number of secondary branches/plant		Vardan x Pusa Mahak	-2.24**
Varuna x RH-819	10.92**	Maya x NDRE-4	-2.37**
NDRE-4 x Pusa Mahak	10.06**	**Oil content**	
RH-9304 x Pusa Mahak	10.67**	Varuan x PusaMahak	10.57**
Number of siliquae on main raceme		Krishna x RH-9304	11.03**
Varuna x Maya	16.93**	Vaibhav x RH-819	7.90**

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 4 : Genotypic and phenotypic correlations co-efficient among seed yield and its contributing characters in Indian mustard

Characters	Days to maturity	Plant height	Number of primary branches/ plant	Number of secondary branches/ plant	Number of siliquae on main raceme	Length of siliquae	Number of seeds/ siliquae	Test weight	Seed yield	Oil content
Days of 50% flowering	rg- 0.032	-0.539	- 0.246	- 0.136	-0.329	0.396	0.221	0.407	-0.007	0.640
	rp– 0.017	-0.473**	- 0.204*	- 0.125	-0.306**	0.320**	0.191*	0.358**	-0.013	0.580**
Days of maturity		rg–0.067	0.103	- 0.473	- 0.141	-0.026	0.177	-0.016	0.084	0.082
		rp–0.061	0.091	- 0.458**	- 0.135	-0.008	0.159	-0.012	0.057	0.079
Plant height			rg-0.351	0.234	- 0.132	-0.219	-0.116	-0.121	0.061	0.497
			rp-0.291**	0.224*	- 0.129	-0.165	-0.094	-0.105	0.045	0.468**
Number of primary branches/plant				rg-0.224	- 0.057	-0.145	-0.042	-0.106	0.057	0.301
				rp-0.029	- 0.044	-0.048	-0.040	-0.085	0.049	0.256**
Number of secondary branches/ plant					rg -0.163	-0.001	-0.083	-0.030	-0.121	0.016
					rp- 0.157	-0.001	-0.075	-0.030	-0.086	0.014
Number of siliqua on main raceme						rg-0.309	-0.392	-0.072	-0.010	0.156
						rp-0.256**	-0.345**	-0.061	0.002	0.150
Length of siliqua							rg -0.175	0.279	-0.042	0.433
							rp -0.130	0.192**	-0.010	0.341*
Number of seeds/ siliqua								rg 0.181	0.026	0.052
								rp 0.137	0.047	0.046
Test weight									rg-0.084	0.368
									srp-0.041	0.322**
Seed yield										rg-0.023
										rp-0.016

Note -* and ** indicate significance of values at P=0.05 and 0.01, respectively

(0.468) and plant height ;seed yield content (0.256) and number of primary branches per plant; length of siliqua (0.256) and number of siliqua on main raceme; test weight (0.192) and length of siliqua; oil content (0.322) and test weight. Positive and significant relationship (P <0.05) between seeds per siliqua, days of 50% flowering, number of secondary branches and plant height also observed by Mishra *et al*. (2007); Singh (2004) and Singh and Singh (2010). We obtained that there was a statistically significant (P<0.01) and negative correlation between plant height (-0.473), number of siliquae on main raceme (-0.306) and days to 50% flowering. Seed yield and oil contents need to be considered under selection of genotypes in experimental programme.

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