Applied Biological Research, 13 (1): 43-47, 2011

COMBINING ABILITY ANALYSIS IN BROWN SARSON (*Brassica rapa* L.) UNDER KASHMIR CONDITIONS

Z.A. Dar, Shafiq A. Wani, Gul Zaffer, M. Habib and I. Ahmed

Division of Plant Breeding and Genetics, S.K. University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar, J&K, 191 121 – India; e-mail:*zahoor3@rediffmail.com*

(Received 5 January, 2011; accepted 15 April, 2011)

ABSTRACT

Six parents and their 15 F_1's of brown sarson from a half diallel cross were evaluated for yield and quality traits over two environments to obtain refined estimates of components of genetic variation which get inflated because of G x E confounding at a single location/year. Analysis of variance revealed significant differences among the parents and their crosses for all the traits. The parents CR-1607, CR-1480, KOS-1 and KS-101 were identified as good general combiners for most of the traits. The cross CR-1485 x CR-1607 proved most desirable for seed yield plant^{-1}, 1000-seed weight, primary branches plant^{-1} and number of seeds siliqua^{-1}. Lines with desirable GCA effects for yield and other attributing traits can be crossed to constitute a base population for subsequent population improvement programmes.

Keywords: *Brassica rapa*, combining ability, gca, recurrent selection, sca

INTRODUCTION

Brown sarson (*Brassica rapa* L.) is one of the most important oleiferous Brassicas cultivated in North-western region of India particularly Kashmir valley where cultivation fits well in rice-oilseed rotation with rice being the major crop. The earlier attempts on improvement of oilseed Brassicas were largely confined to the introduction and selection of desirable lines from available germplasm. The emphasis has gradually been shifted to generate genetic variability in populations for identifying desirable segregants for use in future breeding through hybridization between suitable parents.

Analysis of combining ability is one of the potential tools for identifying the promising hybrids in a set of cross combination (Griffing, 1956). General and specific combining ability effects and variance obtained from a set of F_1's would enable a breeder to select desirable parents towards improvement of quantitative trait among progenies of a cross in subsequent generations (Sprague and Tatum, 1942). Stability in combining ability effects are considerably influenced by environments. A study under different environments is likely to bring out the impact of GxE interaction on the estimate. Several biometrical methods are available for studying the combining ability. During past few decades, several reports have appeared which indicate that diallel analysis is a better method of understanding the genetic nature of the inheritance of the traits and to ascertain the prepotency of parents. Therefore, present analysis was undertaken to develop high yielding varieties (composites) for temperate areas of Kashmir valley in brown sarson.

MATERIALS AND METHODS

The present investigation was conducted during *rabi* season of 2008-09 at two locations viz., Experimental Farm, Division of Plant Breeding and Genetics, SKUAST-K, Shalimar and Experimental Farm, Regional Rice and Research Station (RR&RS), Khudwani, Anantnag. The experimental material consisted of six diverse genotypes of brown sarson (*Brassica rapa* L.) viz., CR-1485, CR-1630, CR-1607, CR-1480, KOS-1 and KS-101 selected from the germplasm collection maintained at RR&RS, Khudwani. Fifteen F_1 crosses (excluding reciprocals) were generated through a 6x6 diallel mating design. The final experimental material comprized of 6 parents and their 15 F_1's. The experiment was laid out in a completely randomized block design with two replications at each location. Recommended agronomic practices were followed to raise a good crop at both the locations. Observations with respect to days to 50% flowering, plant height, primary branches plant^{-1}, secondary branches plant^{-1}, number of siliquae on the main raceme, number of siliquae plant^{-1}, number of seeds siliqua^{-1}, days to maturity, 1000 seed weight, seed yield plant^{-1}, oil content were recorded. Oil content was estimated using NMR (Conway and Earle, 1963). The data were subjected to standard statistical procedures.

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant mean squares for all the traits among all the treatments indicating sufficient amount of variability to be present in the material (Table 1). Mean values of parents and crosses are presented in Table 2.

Table 1: Analysis of variance for maturity, morphological and yield attributing traits in brown sarson (*Brassica rapa*) (pooled over two environments]

Source of variation	d.f.	Days to 50% flowering	Plant height (cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	Siliquae on main raceme (No.)	Siliquae plant^{-1} (No.)	Seeds siliqua^{-1} (No.)	Days to naturity	1000 seed wt (g)	Seed yield plant^{-1} (g)	Oil content (%)
Environment (E)	1	59.4**	85.8**	0.82**	32.2**	176**	85**	8.8**	366.1**	2.15**	3.22**	27.9**
Genotypes (G)	20	19.8**	284.6**	5.04**	4.0**	67**	1991**	0.01	9.1**	0.02	0.01	0.2
Parents (P)	5	10.4**	268.3**	4.09**	1.0**	72**	2321**	16.9**	67.3**	0.65**	5.55**	10.4**
Crosses (C)	14	18.5**	267.9**	3.61**	1.4**	29**	1964**	13.9**	56.3**	0.74**	4.68**	10.6**
P x C	1	163.9**	1162.9*	76.47**	148.5**	1637**	187**	15.39**	69.0**	0.52**	4.40**	8.8**
G xE	20	4.1**	20.4**	0.06**	1.8**	34**	35**	114.76**	88.8**	5.66**	63.77**	77.4**
P xE	5	2.0**	32.5**	0.28**	0.1*	9**	29**	0.03**	22.9**	0.02**	0.05**	0.7**
C xE	14	4.4**	18.1**	0.01**	2.0**	40**	36**	0.04*	16.7**	0.01	0.01**	1.3**
P x C x E	1	9.5**	15.4**	0.29**	7.1**	4**	44**	0.03**	23.8**	0.02**	0.06**	0.6**
Mean error	40	0.21	0.11	0.67	0.05	0.05	14.07	0.01	0.99	0.01	0.01	0.31

The combining ability analysis revealed significant mean squares for general and specific combining ability for all the traits studied. The estimates of variance due to dominance deviation (σ^2_D) were much higher than the corresponding additive genetic variance (σ^2_A) for all the traits, indicating the preponderance of non-additive gene action as compared to additive gene action (Table 3). Similar results have been reported by Kudla (1993), Iqbal *et al*. (2003), Parmar *et al*. (2005) and Amiri-Oghan (2009). Significant gca x environment and sca x environment mean squares were observed for all the traits suggesting that gca and sca were influenced by environmental variations. Ofori and Becker (2007) have reported significant gca x environment and sca x environment interaction in turnip rape. The value ($2\hat{\sigma}^2 g / 2\hat{\sigma}^2 g + \hat{\sigma}^2 s$) was less than unity for all the traits which indicated that performance on general combining ability of parents alone would not be advisable to select materials in segregating generations, but a combination involving both general and specific combining ability of the parents and particular crosses along with their *per se* performance would be more useful in the selection of materials in segregating generations. Nassimi *et al*. (2006) have also reported similar results. The estimates of average degree of dominance exhibited over-dominance for all the traits have previously been reported by Marjanovic *et al*. (2007).

Table 2: Mean performance of parents and crosses for various traits in brown sarson

Crosses	Days to 50% flowering	Plant height (cm)	Primary branches $plant^{-1}$	Secondary branches $plant^{-1}$	Siliquae on main raceme` (No.)	Siliquae $plant^{-1}$ (No.)	Seeds $siliqua^{-1}$ (No.)	Days to maturity	1000 seed weight (g)	Seed yield $plant^{-1}$ (g)	Oil content (%)
CR-1485	171.4	108.6	4.29	3.11	46.45	94.9	15.5	233.3	2.12	3.12	37.20
CR-1630	168.0	101.9	3.82	3.06	37.00	80.7	13.8	225.6	2.19	3.81	38.96
CR-1607	168.6	111.7	4.67	3.68	41.57	120.6	12.8	228.9	2.65	4.03	39.01
CR-1480	170.2	116.1	5.81	2.80	47.40	112.2	13.1	230.7	3.07	4.28	36.10
KOS-1	171.4	113.7	5.18	3.71	40.26	135.5	12.2	225.9	2.43	3.71	34.40
KS-101	171.8	118.3	4.80	2.95	43.31	114.1	13.2	226.9	2.47	3.69	35.17
S.E ± m	0.28	0.61	0.03	0.18	0.80	0.92	0.02	0.65	0.01	0.04	0.05
CR-1485 x CR-1630	165.2	111.5	6.24	6.11	49.39	99.4	16.5	224.4	2.59	3.99	39.74
CR-1485 x CR-1607	168.0	119.6	8.08	6.48	50.12	104.9	17.7	228.7	3.38	6.40	38.25
CR-1485 x CR-1480	168.4	120.0	7.23	5.97	55.71	98.2	16.0	228.2	3.28	5.00	38.22
CR-1485 x CR-1617	169.3	115.8	6.52	5.52	51.33	121.1	18.5	233.1	2.37	5.21	36.38
CR-1485 x KOS-1	170.5	112.5	5.83	6.20	52.20	97.0	16.1	235.6	2.70	4.04	39.06
CR-1485 x KS-101	170.5	121.7	6.24	5.11	50.76	86.4	16.9	235.9	2.85	4.01	39.48
CR-1630 x CR-1607	166.5	96.8	5.79	6.36	50.13	103.7	14.3	231.3	2.89	4.21	38.41
CR-1630 x CR-1480	166.8	104.3	5.76	5.25	50.21	97.7	15.0	227.3	3.20	4.63	37.63
CR-1630 x KOS-1	165.2	113.1	5.65	6.48	49.26	112.1	15.1	220.0	2.41	4.11	41.11
CR-1630 x KS-101	166.3	124.5	5.24	6.49	44.91	101.5	14.6	221.5	3.00	4.10	40.60
CR-1607 x CR-1480	165.8	120.1	7.15	5.47	51.45	132.9	13.3	224.5	3.18	5.66	38.76
CR-1607 x KOS-1	169.4	119.1	5.72	5.70	50.57	126.8	13.4	220.9	2.72	6.36	40.23
CR-1607 x KS-101	165.6	123.5	5.74	5.70	52.65	119.5	13.0	222.7	2.95	4.48	39.94
CR-1480 x KOS-1	167.0	120.7	5.82	4.87	52.79	119.5	13.4	226.5	3.06	4.66	39.07
KOS-1 x KS-101	166.2	130.4	7.17	4.62	51.02	127.6	18.3	222.0	2.80	6.48	39.77
S.E ± m	0.96	2.08	0.11	0.62	2.69	3.09	0.08	2.20	0.06	0.16	0.15

Table 3: Analysis of variance for combining ability and estimates of components of variance for yield and quality traits in brown sarson (*Brassica rapa*)

Source of variation	d.f.	Days to 50% flowering	Plant height (cm)	Primary branches $plant^{-1}$	Secondary branches $plant^{-1}$	Siliquae on main raceme (No.)	Siliquae $plant^{-1}$ (No.)	Seeds $siliqua^{-1}$ (No.)	Days to maturity	1000 seed weight (g)	Seed yield $plant^{-1}$ (g)	Oil content (%)
Environments (E)	1	29.7**	42.9**	0.41**	16.10**	88.25**	42.5**	4.41**	183.0**	1.07**	1.61**	13.95**
Gca	5	28.9**	551.3**	7.80**	1.90**	58.14**	3051.9**	30.71**	105.4**	1.11**	10.52**	13.68**
Sca	14	6.1**	60.5	1.46**	2.05**	28.37**	584.4**	2.85**	19.2**	0.17**	1.61**	3.50**
gca x E	5	3.9**	15.4**	0.05**	1.93**	30.11**	5.8	0.01**	26.7**	0.04**	0.02**	0.33*
sca x E	14	1.6**	9.2**	0.03**	0.71**	14.51**	20.2**	0.02**	8.4**	0.02*	0.03**	0.36**
Pooled	40	0.1	0.3	0.00	0.02	0.15	7.0	0.005	0.5	0.01	0.002	0.16
$\hat{\sigma}^2 g$	-	1.2	22.9	0.32	0.07	2.41	126.9	1.22	4.3	0.06	0.43	0.56
$\hat{\sigma}^2 s$	-	3.0	30.1	0.73	1.01	14.10	288.7	1.46	9.4	0.08	0.61	1.67
$\hat{\sigma}^2 A$	-	4.8	91.8	1.28	0.28	9.64	507.4	4.88	17.4	0.24	1.72	2.24
$\hat{\sigma}^2 D$	-	12.0	120.3	2.92	4.04	56.40	1154.7	5.84	37.5	0.32	2.44	6.68
$\hat{\sigma}^2 A / \hat{\sigma}^2 D$	-	0.4	0.7	0.44	0.06	0.17	0.4	0.83	0.4	0.75	0.70	0.33
$2\hat{\sigma}^2 g / 2\hat{\sigma}^2 g + \hat{\sigma}^2 s$	-	0.4	0.5	-0.45	0.12	0.32	0.5	0.62	0.5	0.60	0.58	0.40
$[\hat{\sigma}^2 D / \hat{\sigma}^2 A]^{1/2}$	-	1.6	1.1	1.51	3.79	2.41	1.5	1.09	2.14	1.33	1.19	1.72

*, ** Significant at 5 and 1% levels, respectively

None of the parents revealed significant and desirable gca effects for all the traits (Table 4). The parents which exhibited desirable and significant gca effects were CR-1630, CR-1607and CR-1480 for early flowering; KOS-1 and KS-101 for plant height; CR-1607 for primary branches plant^{-1}; CR-1485, CR-1630, CR-1607 and KOS-1 for secondary branches plant^{-1}; CR-1480 and CR-1485 for number of siliquae on main raceme; CR-1607 and KOS-1 for number of siliquae plant^{-1}; CR-1485 for number of seeds siliqua^{-1}; CR-1630 and KOS-1 for days to maturity; CR-1607 and CR-1480 for 1000-seed weight; CR-1485, CR-1630 and CR-1480 for seed yield plant^{-1} and CR-1630 and CR-1607 for oil content.

Table 4: Combining ability effects (GCA) for parents and crosses (SCA) for maturity, morphological and yield attributing traits in brown sarson (*Brassica rapa*)

Parents	Days to 50% flowering	Plant height (cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	Siliquae on main raceme (No.)	Siliquae plant^{-1} (No.)	Seeds siliqua^{-1} (No.)	Days to maturity	1000 seed weight (g)	Seed yield plant^{-1} (g)	Oil content (%)
CR-1485	0.84**	-2.8**	-0.09**	0.19**	0.31**	-2.89**	1.30**	0.93**	-0.16**	0.28**	-0.33**
CR-1630	-0.20*	-3.2**	-0.09**	0.16**	-0.73**	-2.58	-0.32**	-0.94**	-0.24**	0.22**	0.66**
CR-1607	-0.27*	-3.3**	0.70**	0.17**	-0.41**	1.88**	-0.21**	0.49**	0.34**	-0.01	0.66**
CR-1480	-0.34*	-0.1	-0.13**	-0.36**	1.57**	-2.78**	-0.31**	0.62**	0.25**	0.38**	-0.93**
KOS-1	0.02	4.0**	-0.18**	0.11**	-0.34**	6.02**	-0.25**	-1.78**	-0.16**	-0.50**	-0.03
KS-101	-0.03	5.4**	-0.18**	-0.28**	-0.39**	0.35	-0.21**	0.07	-0.02	-0.38**	-0.04
SE± (g)	0.05	0.11	0.02	0.03	0.07	0.21	0.01	0.13	0.01	0.01	0.07
SE± (g_i-g_j)	0.06	0.16	0.03	0.04	0.11	0.32	0.03	0.20	0.04	0.02	0.11
CR-1485 x CR-1630	-2.80**	5.2**	0.48**	0.50**	2.53*	4.14*	0.29**	-3.81**	0.08**	0.06	0.65*
CR-1485 x CR-1607	0.12	7.4**	1.59**	0.87**	0.01	-4.85*	1.71**	-0.86	0.60**	1.55**	0.20
CR-1485 x CR-1480	-0.34*	4.7**	0.92**	0.98**	3.62**	-0.85	0.18**	-3.58**	0.28**	0.34**	0.89**
CR-1485 x KOS-1	0.91**	-3.9**	-0.13**	0.74**	2.02**	-16.41**	0.61**	7.57**	0.12**	-0.35**	0.77*
CR-1485 x KS-101	1.34**	0.8*	0.28**	-0.04	1.23**	-22.29**	1.23**	6.74**	0.13**	-0.47**	1.26**
CR-1630 x CR-1607	0.39*	-11.1**	-0.09**	0.78**	3.99**	-9.70**	-0.26**	6.57**	0.18**	-0.31**	-1.79**
CR-1630 x CR-1480	-0.20	-6.7**	0.05	0.29**	2.09**	-5.05*	0.54**	0.39	0.28**	0.31**	-0.84**
CR-1630 x KOS-1	-2.64**	1.0*	0.28*	1.05**	3.05**	-4.91*	0.99**	-3.11**	-0.09**	0.08*	1.67**
CR-1630 x KS-101	-1.13**	7.9**	-0.11**	1.36**	-0.64*	-10.84**	0.33**	-2.78**	0.35**	-0.04	1.22**
CR-1607 x CR-1480	-1.14**	3.1**	0.70**	0.49**	0.08	15.73**	-0.86**	-3.83**	-0.01	0.33**	0.31
CR-1607 x KOS-1	1.57**	1.1**	-0.37*	0.27**	1.12**	-4.73*	-0.48**	-3.66**	-0.06	-0.57**	0.83**
CR-1607 x KS-101	-1.79**	1.0*	-0.35**	0.56**	3.85**	-7.36**	-1.04**	-3.09**	0.02	-0.58**	0.59*
CR-1480 x KOS-1	-1.67**	-0.4	-0.10*	0.06	1.36**	-1.34**	-0.36**	-0.22	0.07*	-0.08*	1.38**
CR-1480 x KS-101	0.10	4.2**	-0.20**	0.49**	2.66**	-2.08	-0.04	2.25**	0.08*	-0.09*	0.90*
KOS-1 x KS-101	-0.16	1.9**	-0.41*	-0.16	-4.91**	12.45**	-0.24**	-0.38	-0.21**	0.14**	1.26**
S.E ±(S_{ij})	0.146	0.37	0.036	0.094	0.233	1.73	0.04	0.45	0.03	0.03	0.26
S.E ±(S_{ij} – S_{ik})	0.224	0.56	0.042	0.156	0.370	2.54	0.07	0.67	0.05	0.04	0.38

*, ** Significant at 5 and 1% levels, respectively

The study of sca effects revealed that none of the crosses was a desirable specific combiner for all the traits under study. Different crosses were found desirable for different traits. Desirable cross combinations for days to 50% flowering and days to maturity were CR-1485 x CR-1630, CR-1485 x CR-1480, CR-1630 x KOS-1, CR-1630 x KS-101, CR-1607 x CR-1480 and CR-1607 x KS-101; for plant height, primary branches plant^{-1} and secondary branches plant^{-1} were CR-1485 x CR-1630, CR-1485 x CR-1607, CR-1485 x CR-1480, CR-1630 x KOS-1 and CR-1607 x CR-1480; for number of siliquae on main raceme, number of siliquae plant^{-1} and number of seeds siliqua^{-1} were CR-1485 x CR-1630; for 1000-seed weight and seed yield plant^{-1} were CR-1485 x CR-1607, CR-1485 x CR-1480 and CR-1630 x CR-1480 and for oil content most of the crosses were found desirable. The crosses were mostly the result of high x low or low x low or low x average general combiners. Sheoran *et al.* (2000), Ghosh *et al.* (2002), Singh *et al.* (2003) and Yogeshwar and Sachan (2003) reported similar results in case of Indian mustard.

Conclusions: Based on these findings, it may be concluded that some of the promising parental lines need to be crossed to other elite genetic materials to broaden the genetic base. The lines with desirable GCA effects for seed yield and other agronomic attributes like CR-1607, CR-1480, KOS-1 and KS-101could be crossed *inter-se* to constitute the base population and subsequent recurrent selection efforts would facilitate derivation of superior genotypes.

Acknowledgement: The authors wish to thank ITK Germany for providing germplasm for the study and Directorate of Rapeseed-Mustard, Bharatpur, India for providing facility for oil extraction.

REFERENCES

Amiri-Oghan, H., Fotokian, M.H., Javidfar,F. and Alizadeh, B. 2009. Genetic analysis of grain yield, days to flowering and maturity in oilseed rape (*Brassica napus* L.) using diallel crosses. *International Journal of Plant Production,* **3**(2): 19-26.

Conway, T.F. and Earle, F.R. 1963. Nuclear magnetic Resonance for determining oil content of seeds. *Journal of the American Oil Chemists Society*, **40**: 265-268

Ghosh, S.K., Gulati, S.C. and Raman, R. 2002. Combining ability and heterosis for seed yield and its components in Indian mustard (*Brassica juncea* (L.) Czern and Cross.). *Indian Journal of Genetics and Plant Breeding,* **62**: 29-33.

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. *Australian Journal of Biological Sciences,* **9**: 463-493.

Iqbal, M.M., Noshin, R. and Khan, S.J. 2003. Use of diallel analysis to examine the mode of inheritance of agronomic and quality parameters in F_1 generation of brown mustard. *Asian Journal of Plant Science,* **2**: 1040-1046.

Kudla, M. 1993. Combining ability of inbred lines and heterosis effects in hybrids of winter swede rape. *Biuletyn Instytutu Hodowlii Aklimatyzacji Roslin*, **186**: 3-11 [c.f. Crop CD 2000/01 AN: 941602228].

Marjanovic, A.J., Marikovic, R. and Miladinovic, D. 2007. Combining abilities of rapeseed (*Brassica napus* L.) varieties. *Genetika,* **39**: 53-62.

Nassimi, A.W., Raziuddin, Ali, N., Ali,S. and Bakht, J. 2006. Analysis of combining ability in *Brassica napus* lines for yield associated traits. *Pakistan Journal of Biological Sciences,* **9**: 2333-2337.

Ofori, A. and Becker, H.C. 2007. Heterosis and combining ability in *Brassica rapa* population for biomass production. pp. 140-142. In: *Proceedings of 12^th^ International Rapeseed Congress,* 26-30 March, 2007, Wuhan, China.

Parmar, M.B., Patel, K.M. and Prajapati, K.P. 2005. Assessment of genetic worth of parents and hybrids in Indian mustard, *Brassica juncea* (L.) Czern and Coss. *Journal of Oilseeds Research,* **22**: 12-14.

Sheoran, R.K., Yadav, I.S., Singh, A. and Singh, B. 2000. Combining ability analysis for various characters in brown sarson. *Journal of Oilseeds Research,* **17**: 81- 86.

Singh A.K., Singh, B. and Sachan, J.N. 2003. Diallel analysis for combining ability for yield and its components including oil content in Indian mustard. *Journal of Oilseeds Research,* **20**: 269- 271.

Sprague, G.F. and Tatum, L.A. 1942. General versus specific combining ability in single crosses of corn. *Journal of American Society of Agronomy,* **34**: 923-932.

Yogeshwar and Sachan, J.N. 2003. Combining ability analysis for seed yield and its components in Indian mustard (*Brassica juncea* (L.). *Indian Journal of Genetics and Plant Breeding,* **63**: 83-84.