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STUDY OF COMBINING ABILITY AND HETEROSIS FOR SEED YIELD AND SEED QUALITY TRAITS IN RAPESEED [*BRASSICA RAPA* L.]

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ABSTRACT

Combining ability, gene action and heterosis was studied in a set of nine parents, their 36 hybrids and one standard check (Benoy) of rapeseed following half diallel analysis. The ratio of $\acute{o}^2_{gca} / \acute{o}^2_{sca}$ suggested predominance of non- additive gene effects for all the characters except days to maturity. Based on general combining ability effects the parents GS 1 and PS 66 were good general combiners for seed yield per plant and component traits. While parents SPAN, AA 14 and SSK 9203 proved to be good general combiners for quality traits *viz*., oil content (%), erucic acid (%). The cross combinations NDYS 53-1 x AA 14 ,YSB 2001 x SSK 9203 and SPAN x SSK 9203 exhibited significant sca effects for seed yield per plant and its associated traits. The promising crosses based on standard heterosis were PS 66 x YSB 2001, GS 1 x YSB 2001 and GS 1 x YSB 4-2005. The hybrids PS 66 x NDYS 53-1 and SSK 9203 x AA14 were found promising based on high sca and heterosis for oil content and erucic acid.

INTRODUCTION

Sarson [*Brassica rapa* (L.)] commonly known as yellow sarson is a plant widely cultivated as a major source of vegetable oil, which come from *Brassica* sp. It has higher oil content as compared to Indian mustard. Among different oilseed crops grown, rapeseed-mustard is the third most important oil yielding crops of Indian subcontinent after soybean and groundnut. These crops account for 6.51 million hectares of the area and producing 7.67 million tonnes of total production, contributing more than 22.7 per cent of total oilseed production of our country. The productivity of rapeseed-mustard in India (893 kg/ha) is far behind as compared to that of the Germany (3657 kg /ha) and global average (1511 kg/ha) (USDA, 2012). Oil and fats are essential items in human diets since they provide energy, improve taste and palatability of food. Oilseed crops are next to cereals in production of agricultural commodities in India, which occupy a place of prime importance in indian economy. (Neelam Shekhawat *et al*., 2011)

Looking to average productivity data cited above, it is quite clear that still there is considerable scope for increasing yield potential of rapeseed-mustard crop in India through genetic improvement. In Indian sub-continent, the major objective of crop improvement programme in case of rapeseed is to develop high yielding varieties. This can be accomplished by breeding for better plant type, incorporation of disease and pest resistance, fertilizer responsiveness and by adopting other approaches. In rapeseed breeding programme, breeding techniques of both self and cross pollinated crops are widely used for the development of improved cultivars. Exploitation of hybrid vigour has been recognized as an important tool for making genetic improvement of yield and yield attributing characters in rapeseed and may serve as a major technique to break existing yield barriers. 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 better combining parents for different traits. Therefore, proper understanding of combining ability of parents and nature of gene action governing yield and its component traits could be of great help in selecting parents for the hybridization programme. Many authors applied different strategies for improving seed yield and quality attributes of Brassica (Singh *et al*, 2003; Gami *et al,* 2012). Gami and Chauhan (2013) and Patel *et al*., (2013) have also reported different types of gene action and combining abilities in different sets of material studies in Indian mustard.

Diallel analysis is a systematic approach for identification of superior parents and crosses, which are the basic materials on which the success of a breeding programme rests. It is widely used in crop plants for testing the performance of genotypes in hybrid combination and also for characterizing magnitude and nature of gene action involved in controlling quantitative characters (Griffing, 1956b). Keeping these in view the present investigation was undertaken to make an assessment of combining ability, gene action and heterosis of parents and their specific cross in rapeseed with the help of half diallel analysis.

MATERIALS AND METHODS

The experimental material consisted of nine parents (PS 66, GS 1, YSB 4-2005, YSB 2001, RS 1, NDYS 53-1, SPAN, SSK 9203 and AA 14) crossed in a half diallel fashion. The resultant 36 hybrids along with their nine parents and one check variety (Benoy) were evaluated in Randomized Block Design with three replications at Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *rabi* 2013-2014. Five representative plants were taken from each plot for recording data on different characters *viz*., days to 50% flowering, days to maturity, plant height (cm), number of siliquae on main branch, total silique per plant, siliquae length (cm), number of seeds per silique, number of branches per plant, seed yield per plant (g), 1000-seed weight (g), harvest index (%), oil content (%) and erucic acid (%). Oil content of each sample was estimated in percentage by using Nuclear Magnetic Resonance Technique (Tiwari *et al*., 1974), while erucic acid of each sample was estimated in percentage by using Fourier Transferable Near Infrared (FT-NIR) Technique. The data were subjected to analysis of variance as per the procedure suggested by Sukhatme and Amble (1989). The combining ability analysis was performed for 45 entries (Parents and hybrids) according to the procedure given by Griffing (1956a), as per Method-II and Model-I. The hybrid performance (%) tested in comparison with mean value of mid parent (Relative heterosis), Briggle (1963), better parent [(Heterobeltiosis/BPH) Fonseca and Patterson (1968)] and standard parent/check [(standard heterosis/SH) Meredith and Bridge (1972)]. Significance of heterosis value was tested using 't' test.

$$t = \frac{\overline{F}_1 - \overline{MP} \text{ or } \overline{BP} \text{ or } \overline{SC}}{\text{S.E. of heterosis over MP or BP or SC}}$$

Where;

Calculated 't' values were compared with tabulated 't' values at error degree of freedom for test of significance

RESULTS AND DISCUSSION

Analysis of variance indicates that mean squares due to parents as well as hybrids were significant which depicted presence of adequate variability in them for all the characters. Comparison of mean squares due to parents vs. hybrids was found to be significant for days to 50% flowering, number of branches per plant, seed yield, oil content and erucic acid. This indicates that average performance of hybrids significantly differed from that of the parents as a group of these traits suggesting the presence of sufficient variability for all these characters. (Table 1).

The analysis of variance for combining ability indicated that the mean squares due to general combining ability and specific combining ability were significant for all the characters under study. The variance due to sca was higher than that of due to gca for all the characters except days to maturity due to the predominant role of non-additive gene action (Table 2). These results were in agreement with the findings of Rahman

Table 1: Analysis of variance (mean squares) for experimental design for various characters in sarson

Source of variation	d.f.	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of siliquae on main branch	Total siliquae per plant	Silique length (cm)	Number of seeds per silique	Number of branches per plant	1000-seed weight(g)	Seed yield per plant (g)	Harvest Index (%)	Oil content (%)	Erucic acid (%)
Replications	2	1.67	3.47	543.63 **	0.55	52.49	0.11	3.01	8.87 **	0.17	2.30	1.61	0.008	0.06
Genotypes (G)	44	90.05 **	43.63 ***	587.64 **	37.40 **	3613.29 **	0.63 **	38.76 **	10.51 **	0.71**	79.10 **	184.11 **	85.82 **	52.08**
Parents (P)	8	127.42 **	36.57 **	872.11 **	35.80 **	3542.65 **	0.46 *	37.30 **	6.86 **	0.71 **	109.49 **	229.26 **	122.05 **	45.52**
Hybrids (H)	35	75.91 **	46.31 **	534.42 **	38.45 **	3695.85 **	0.68 **	40.19 **	11.21 **	0.72 **	73.02 **	178.93 **	73.64 **	53.65 **
Parent *vs*.Hybrids	1	286.02 **	6.45	174.41	13.68	1288.69	0.004	0.17	15.27 **	0.50	48.66**	4.27	222.04 **	49.71**
Error	88	2.568	12.11	110.11	4.12	447.98	0.19	3.23	0.70	0.17	4.43	6.59	0.51	0.31

*, ** indicate level of significance at 5 % and 1 %, respectively

Table 2: Analysis of variance (mean squares) for combining ability and estimates of variance components for different characters in sarson.

Source of variation	d.f.	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of siliquae on main branch	Total siliquae per plant	Silique length (cm)	Number of seeds per silique	Number of branches per plant	1000-seed weight (g)	Seed yield per plant (g)	Harvest Index (%)	Oil content (%)	Erucic acid (%)
GCA	8	54.30**	50.20**	561.23**	32.69**	3145.09**	0.44**	40.50**	8.27**	0.29**	37.75**	113.90**	20.39**	29.52**
SCA	36	24.62**	6.62*	114.69**	7.97**	773.17**	0.16**	6.79**	2.44**	0.23**	23.84**	49.70**	30.43**	14.66**
Error	88	0.86	4.04	36.70	1.37	149.33	0.06	1.08	0.23	0.06	1.48	2.20	0.17	0.10
s^2gca		4.86	4.20	47.68	2.85	272.34	0.03	3.58	0.73	0.02	3.30	10.15	1.84	2.67
s^2sca		23.77	2.58	77.99	6.60	623.85	0.10	5.71	2.21	0.17	22.36	47.50	30.26	14.55
s^2gca/s^2sca		0.20	1.62	0.61	0.43	0.44	0.36	0.63	0.33	0.13	0.15	0.21	0.06	0.18

*, ** indicate level of significance at 5 % and 1 %, respectively.

Table 3a: 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 variety Benoy

Characters	Best performing parents	Best general combiners	Best performing hybrids		Hybrids with high sca effects		Sca effects	Heterosis over BP	Heterosis over SC-Benoy
Days to50 %flowering	GS 1	RS 1	SSK 9023 x AA 14	P x P	PS 66 x AA 14	P x P	-9.44**	-23.08**	-8.50**
	RS 1	GS 1	SPAN x AA 14	G x P	PS 66 x YSB 2001	P x A	-8.29**	-24.18**	-9.80**
	SPAN	-	RS 1 x SPAN	P x G	SSK 9203 x AA 14	P x P	-5.32**	-13.71**	-1.31
Days to maturity	PS 66	PS 66	PS 66 x YSB 2001	P x G	PS 66 x YSB 2001	G x A	-7.06**	-3.36	-7.60**
	NDYS 53-1	GS 1	PS 66 x GS A	P x G	GS 1 x SPAN	G x G	-4.42*	-5.85*	-5.85*
	GS 1	SPAN	GS 1 x SPAN	G x G	SPAN x AA 14	G x P	-3.42	-1.46	-1.17
Plant height (cm)	PS 66	PS 66	GS 1 x SSK 9203	G x P	GS 1 x SSK 9203	G x A	-19.02**	-13.13*	-14.92**
	YSB 4-2005	GS 1	GS 1 x NDYS 53-1	G x P	RS 1 x SSK 9203	P x A	-15.17**	-3.42	-1.96
	GS 1	AA 14	GS 1 x SPAN	G x G	YSB 4-2005 x YSB 2001	A x P	-15.04*	-	-1.39
Number of siliquae on main branch	GS 1	GS 1	GS 1 x YSB 2001	G x G	YSB 2001 x SSK 9203	G x P	4.62**	14.00*	6.15
	YSB 4-2005	YSB 2001	PS 66 x YSB 2001	P x G	NDYS 53-1 x AA 14	P x P	4.34**	22.56**	-
	RS 1	YSB 4-2005	YSB 4-2005 x YSB 2001	A x G	PS 66 x YSB 2001	G x G	3.55**	10.93*	11.29*
Total siliquae per plant	GS 1	GS 1	GS 1 x YSB 2001	G x G	YSB 2001 x SSK 9203	G x P	46.76**	14.00*	2.83
	RS 1	YSB 2001	PS 66 x YSB 2001	P x G	NDYS 53-1 x AA 14	P x P	42.42**	22.56**	-
	YSB 4-2005	YSB 4-2005	YSB 4-2005 x YSB 2001	A x G	PS 66 x YSB 2001	G x G	36.62**	10.93	7.81
Silique length (cm)	YSB 2001	YSB 2001	GS 1 x YSB 2001	G x G	PS 66 x YSB 2001	A x G	0.90**	11.28*	21.91**
	YSB 4-2005	RS 1	YSB 4-2005 x YSB 2001	A x G	YSB 2001 x SSK 9203	G x P	0.56*	3.08	12.92*
	RS 1	GS 1	YSB 2001 x RS 1	G x P	RS 1 x SPAN	A x A	0.55*	4.21	11.24

* and ** significant at P = 0.05 and P = 0.01, respectively; G = Good, A = Average, P = Poor.

et al. (2011), Dar *et al.* (2011) and Patel *et al.* (2013).

Based on combining ability analysis, the traits *viz.,* number of branches per plant, total siliquae per plant and 1000-seed weight were the most potent characters among the yield components. While based on the estimates of general combining ability effects, none of the parents was good general combiner for all the traits under study. The parent GS 1 and PS 66 were good general combiner for seed yield per plant, days to maturity, plant height, number of branches per plant, number of siliquae on main branch, total siliquae per plant and number of seeds per siliquae The parent GS 1 also proved to be a good combiner for days to 50% flowering, 1000-seed weight and harvest index. The parent YSB 2001 showed also good general combining ability for yield and all the yield attributing characters. Therefore, GS 1, PS 66 and YSB 2001 can be considered as a good source of favorable genes for increasing seed yield along with other yield attributes. It is evident from the results that high gca effects for seed yield per plant in the varieties GS 1, PS 66 and YSB 2001 were mainly due to better yield contributing characters. Therefore, it would be worthwhile to use above parental lines in the hybridization programme (Table 3a).

For quality components, parents SPAN, RS 1 and AA 14 were found to be good general combiners for oil content and erucic acid, while, the parents YSB 4-2005 and NDYS 53-1 showed good general combining ability in terms of oil content, while SSK 9203 for erucic acid (Table 3b).

The estimates of specific combining ability effects revealed that as many as 14 cross combinations exhibited significant and positive sca effects for seed yield per plant. Maximum significant and positive sca effect was manifested by hybrids NDYS 53-1 x AA 14 (6.43), YSB 2001 x SSK 9203 (6.37) and SPAN x SSK 9203 (6.20) thus, they were good hybrid combinations, contributing towards higher seed yield. The best three crosses selected each for sca effects, *per se* performance and heterobeltiosis for all the characters are present in Table 3b. The crosses NDYS 53-1 x AA 14 (6.43), YSB 2001 x SSK 9203 (6.37) and SPAN x SSK 9203 (6.20) recorded high and significant sca effects for seed yield which could be resulted from either Poor x Poor or Good x Poor general combiners.

A close examination of performance of hybrids over better parent revealed that eight hybrids manifested significant positive heterobeltiosis for seed yield per plant. The maximum heterobeltiosis for seed yield per plant was exhibited by the hybrid SSK 9203 x AA 14 (57.88). The superior hybrids exhibited significant heterosis over better parent in desirable direction for different component traits such as days to 50% flowering (PS 66 x YSB 2001), days to maturity (GS 1 x SPAN), number of siliquae on main branch (NDYS 53-1 x AA 14, YSB 2001 x SSK 9203 and PS 66 x YSB 2001), number of branches per plant (YSB 2001 x SSK 9203 and PS 66 x YSB 2001), total siliquae per plant (NDYS 53-1 x AA 14 and YSB 2001 x SSK 9203), silique length (PS 66 x YSB 2001), number of seeds per silique (NDYS 53-1 x AA 14 and GS 1 x SSK 9203), 1000-seed weight (RS 1 x SSK 9203), harvest index (8), oil content (7), and erucic acid (27). These findings were also supported by Qian *et al.* (2007), Sabaghnia *et al.* (2010) and Dar *et al.* (2011).

Table 3b: 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 variety Benoy

Characters	Best performing parents	Best general combiners	Best performing hybrids		Hybrids with high sca effects		Sca effects	Heterosis over	
Number of seeds per silique	YSB 2001	YSB 2001	GS 1 x YSB 2001	G x G	NDYS 53-1 x AA 14	P x P	4.91**	31.16**	2.63
	PS 66	YSB 4-2005	YSB 4-2005 x YSB 2001	A x G	YSB 2001 x SSK 9203	G x P	4.46**	0.92	12.70
	YSB 4-2005	GS 1	YSB 2001 x SSK 9203	G x P	YSB 4-2005 x AA 14	G x P	4.11**	10.27	8.18
Number of branches per plant	GS 1	GS 1	GS 1 x YSB 2001	G x G	GS 1 x YSB 2001	G x G	2.23**	8.22	23.92**
	RS 1	YSB 2001	GS 1 x RS 1	G x P	YSB 2001 x SSK 9203	G x P	2.22**	14.25*	6.11
	YSB 4-2005	YSB 4-2005	YSB 4-2005 x YSB 2001	A x G	YSB 4-2005 x YSB 2001	G x G	1.56**	7.84	15.52**
1000- seed weight (g)	GS 1	GS 1	PS 66 x AA 14	P x P	RS 1 x SSK 9203	A x P	0.89**	24.59**	21.72**
	YSB 2001	YSB 2001	PS 66 x YSB 2001	P x G	PS 66 x AA 14	A x A	0.74**	4.66	23.23**
	SPAN	PS 66	RS 1 x SSK 9203	P x P	RS 1 x SPAN	A x A	0.68**	0.49	19.55**
Seed yield per plant (g)	SPAN	GS 1	PS 66 x YSB 2001	P x G	NDYS 53-1 x AA 14	P x P	6.43**	14.41*	2.05
	GS 1	PS 66	GS 1 x YSB 2001	G x G	YSB 2001 x SSK 9203	G x P	6.37**	17.37**	11.66*
	PS 66	YSB 2001	GS 1 x YSB 4-2005	G x A	SPAN x SSK 9203	P x P	6.20**	-	3.24
Harvest Index (%)	YSB 4-2005	GS 1	GS 1 x YSB 2001	G x G	PS 66 x YSB 2001	P x G	12.59**	40.00**	20.49**
	SPAN	YSB 2001	GS 1 x YSB 4-2005	G x A	NDYS 53-1 x AA 14	P x P	11.66**	36.56**	4.10
	GS 1	YSB 4-2005	PS 66 x YSB 2001	P x G	YSB 2001 x SSK 9203	G x A	9.02**	34.29**	15.57**
Oil content (%)	SPAN	SPAN	PS 66 x NDYS 53-1	P x P	GS 1 x YSB 2001	P x P	5.38**	6.68**	6.04**
	SSK 9203	RS 1	YSB 2001 x NDYS 53-1	G x P	PS 66 x NDYS 53-1	P x G	5.30**	5.35**	12.16**
	NDYS 53-1	AA 14	YSB 4-2005 x RS 1	A x P	PS 66 x SSK 9203	P x P	3.73**	-	2.42
Erucic acid (%)	SPAN	SPAN	SSK 9203 x AA 14	P x P	SSK 9203 x AA 14	G x G	-13.85**	-25.82**	-39.06**
	SSK 9203	SSK 9203	SPAN x AA 14	G x P	GS 1 x YSB 2001	P x P	-5.13**	-6.12**	-14.61**
	RS 1	AA 14	RS 1 x SPAN	P x G	YSB 2001 x AA 14	P x G	-3.11**	-7.14**	-16.26**

* and ** significant at P = 0.05 and P = 0.01, respectively; G = Good, A = Average, P = Poor.

In case of standard heterosis, three hybrids *viz*. PS 66 x YSB 2001 (19.55%), GS 1 x YSB 2001 (19.22%), and GS 1 x YSB 4-2005 (11.77%) showed significant positive heterosis over the standard check Benoy for seed yield. The heterotic response over the standard check in Indian mustard were also reported by Singh *et al*. (2009), Patel *et al*. (2010) and Gami and Chauhan (2013), which were in accordance with the present findings.

The promising crosses based on standard heterosis were PS 66 x YSB 2001, GS1 x YSB 2001 and GS 1 x YSB 4-2005. The hybrids PS66 x NDYS 53-1 and SSK 9203 x AA14 were found promising based on high sca and heterosis for oil content and erucic acid (Table 3b). For oil content, the values for relative heterosis, heterobeltiosis and standard heterosis were high. Similarly, the values for erucic acid were low. Similar results were also found by Patel and Sharma (1999), Singh *et al*. (2003), Wang *et al*. (2009) and Gami and Chauhan (2014).

It is clear from the above discussion that the parent GS1 and YSB2001 are good combiners for yield and its components traits. While crosses PS 66 x YSB 2001, GS 1 x YSB 2001and GS 1 x YSB 4-2005 found to be most promising for seed yield and other desirable traits, hence these hybrids could be further evaluated to exploit the heterosis after identifying suitable hybrid seed production technology and in future breeding programme by utilizing biparental mating or recurrent selection breeding approaches to obtain desirable segregants for development of further superior genotypes for seed yield and its component traits.

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APPLICATION FORM

NATIONAL ENVIRONMENTALISTS ASSOCIATION (N.E.A.)

To,
The Secretary,
National Environmentalists Association,
D-13, H.H.Colony,
Ranchi - 834 002, Jharkhand, India

Sir,
I wish to become an Annual / Life member and Fellow* of the association and will abide by the rules and regulations of the association

Name ______________________________

Mailing Address ______________________________

____

Official Address ______________________________

____

E-mail ____________________ Ph. No.__________(R)__________(O)

Date of Birth ____________________ Mobile No. ____________________

Qualification ______________________________

Field of specialization & research ______________________________

Extension work (if done) ______________________________

____

Please find enclosed a D/D of Rs.. No. .... Dated .... as an *Annual / Life membership fee*.

*Attach **Bio-data and some recent publications along with the application form when applying for the Fellowship of the association.**

Correspondance for membership and/ or Fellowship should be done on the following address :

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Ranchi - 834002
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