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COMBINING ABILITY ANALYSIS FOR SEED YIELD AND ITS ATTRIBUTES IN YELLOW SARSON (*BRASSICA RAPA* L.) UNDER TIMELY AND LATE SOWN CONDITIONS

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ABSTRACT

The occurrence of combining ability analysis for oil content, seed yield and some yield components has been studied in 45 F_1 combinations derived from ten parental genotypes (YST151, Jagrati, NDYS 424, NDYS 425, Ragini, NDYS 427, NDYS 116-1, NDYS 08-01, NDYS 07-02 and Pusa Gold) of yellow *sarson* according to a diallel design in the 2010 and 2011 seasons. The gca and sca effects showed highly significant for all characters in both environments (E_1 and E_2). This signified the importance of both additive and non additive gene effects in controlling the inheritance of traits studies. The parents Ragani, NDYS 07-02 and Pusa gold were identified as best general combiners for yield and yield contributing characters. Whereas, best five specific cross combinations were Ragini x NDYS 07-02, Ragini x NDYS 116-1, YST-151 x Jagrati, NDYS 424 x NDYS 07-02 and YST-151 x NDYS 08-01 in timely sown and in case of late sown condition best five crosses namely viz., NDYS 427 x NDYS 08-01, Ragini x NDYS 116-1, YST-151 x NDYS 425, NDYS 424 x NDYS 116-1 and Ragini x NDYS 07-02, were identified as good specific combinations for seed yield and its attributed traits.

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INTRODUCTION

India is one of the important rapeseed- mustard growing country in the world occupying second position in area after China and third position in production after China and Canada (Anonymous, 2010). The oilseeds are important and next to food grains in terms of area, production and value. Oilseed *Brassica* is commonly known as rapeseed-mustard and occupy an important position in the rainfed agriculture of our country because of low water requirement (80-240 mm), these crops fit well in rainfed cropping system. Rapeseed-mustard occupies a prominent place being next to groundnut and soybean in contribution to oilseed production (Kumar and Chauhan, 2005). In India, the total production of rapeseed-mustard continuous increasing since 1978 was 1.6 m tonnes with an area of 3.54 m hectares which increased in 2010-11 by 7.67 Mt. in an area of 6.51 Mha. with the productivity of about 1179 kg ha^{-1}. Rajasthan is leading state in production accounting 2.95 (44.61%) million tones however, highest productivity of Rapeseed & Mustard is recorded in Haryana (1655 kg ha^{-1}).

Combining ability concepts are the basic tools for improved production of crops in the form of F_1 hybrids. Combining ability studies have significant importance in determining the type of gene action present in controlling a character. Additive type of gene action is indicated by general combining ability variance while non-additive type of gene action is shown by specific combining ability variance, originating mainly from dominance and epistasis deviations (Malik *et al.,* 2004). The mean values are used for predicting combining ability of the parents (GCA) and hybrids (SCA) to enlighten the nature of gene action involved in the inheritance of traits. The yield advancement in *brassica* requires information regarding the nature of different combining abilities of parents and also knows how about the nature of gene action involved in expression of different quantitative and qualitative traits of economic importance. In breeding programs, the GCA and SCA are usually used for parents and their cross combinations selection, respectively for improvement of crop production (Singh *et al*., 2003). The present study aims to identify the best general combiners and their F_1 hybrids on the basis of their general, specific and reciprocal combining ability for yield and its contributing traits.

MATERIALS AND METHODS

The experimental material for present investigation comprised of ten parents of yellow *sarson,* 45 F'_1s which were developed by crossing 10 diverse lines *viz*., YST151, Jagrati, NDYS 424, NDYS 425, Ragini, NDYS 427, NDYS 116-1, NDYS 08-01, NDYS 07-02 and Pusa Gold in all possible combinations excluding reciprocals. A total of 56 genotypes (45 F_1's + 10 parents + 1 standard variety NDYS 2) were grown in Randomized Block Design with three replications in two environments (timely sown and late sown) on 26th October (E_1) and 27th November (E_2), respectively at Research Farm of Department of Genetics & Plant Breeding, Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad (U.P.) during *rabi*, 2010-11. Each entry was sown in a single row of 5 m length with inter and intra-row spacing of 45 cm and 10 cm, respectively. The distance between

plants to plant was maintained by thinning after 15 days of sowing. All recommended agronomical practices and plant protection measures were adopted for raising the good crop. The observations were recorded on five randomly selected plants in each replication for every entry for all the characters except days to 50 percent flowering and days to maturity where, the observations were recorded on the plot basis. The mean of each plot was used for statistical analysis. Combining ability is a statistical procedure used for analysis of diallel crosses in a universal theoretical form (Griffing, 1956). It works as a principal method for screening of germplasm and to determine the ability of the different genotypes to be included or not in a future breeding programme on the basis of their GCA, SCA and reciprocal effects.

RESULTS AND DISCUSSION

In present study, analysis of variance showed highly significant for all the traits indicating significant variability among all the genotypes studied (Table 1) (Kumar *et al.,* 2013, and Kumar *et al.,* 2014). Results examination of the magnitude of mean square revealed significant differences for general and specific combining ability for all the traits under both timely and late sown conditions. Higher value of variance for general combining ability than specific combining ability for all characters except seed yield per plant (E_1) revealed that these traits were predominantly controlled by additive gene action and it was supported by Parmar *et al*. (2004) and Singh *et al*. (2008) as they denoted prominence of additive gene action for these traits. I observed that none of the parents was good general combiner for all the characters. Estimates of gca and sca variances revealed that non-additive gene action was important in the expression of different characters in both the conditions. In analytical study the average degree of dominance showed over dominance for all characters in both timely and late sown condition except plant height, number of primary branches, length of fruiting zone, number of siliquae on main raceme and seeds per siliqua. High value of sca variance and the average degree of dominance were more revealing there by over dominance, for all the characters in both timely and late sown conditions. Similar findings were also reported by earlier workers Singh *et al*. (2008), Kumar *et al*. (2007), Kumar *et al*. (2004). Relative magnitude of non-additive gene effects was predominant in controlling the inheritance of plant height, number of primary branches and seed yield per plant, whereas, additive gene effects were found predominant for controlling the inheritance of rest of the characters. The combining ability analysis was done for 10 parents and their 45 F_1's. The results are described below.

General combining ability

General combining ability study helps in making the choice of the parents and also helps in the isolation of suitable germplasm for further improvement. General combining ability is primarily a function of additive and additive x additive gene action. In the present study and on the basis of gca, parent, YST-151 was found good general combiner for plant height, length of fruiting zone, number of siliquae on main raceme; Jagrati, for days to maturity, plant height, length of fruiting zone; NDYS 424 for plant height, seeds per siliqua, biological yield per plant, seed yield per plant, harvest index; NDYS 425 for plant height, length of fruiting zone, number of siliquae on main raceme; Ragini for days to 50% flowering, days to maturity, number of primary branches per plant, seeds per siliqua, 1000-seed weight, seed yield per plant, harvest index; NDYS 427 days to 50% flowering, number of primary branches per plant, length of fruiting zone, biological yield per plant, oil content; NDYS 116-1 for number of siliquae on main raceme; NDYS 08-01 for seeds per siliqua, oil content; NDYS 07-2 for days to 50% flowering, number of primary, branches per plant, seeds per siliqua, biological yield per plant, seed yield per plant, harvest index; Pusa Gold for plant height, length of fruiting zone, number of siliquae on main raceme, 1000-seed weight and oil content. These strains/varieties can successfully be utilized for improving characters for which improvement is desired. The above findings are in conformity with the findings of Tripathi (2002) and Katiyar *et al*. (2004).

Specific combining ability

Specific combining ability is a function of non-additive gene action, where the crosses showing high sca effects, could be exploited in future breeding programme. Darrah and Hallaur (1972) pointed out that poor inbreds though lacked the

Table 1: ANOVA of combining ability for 12 characters in 10 x 10 diallel crosses of yellow *sarson* under timely sown and late sown conditions

Source	d.f.	Characters Environment	Days to 50 % Flowering	Days to Maturity	Plant Height	No. of primary branches	Length of fruiting zone	No. of siliquae on main raceme	Seeds per siliqua	1000-seed weight (g)	Seed yield per plant (g)	Biological yield per plant (g)	Harvest index	Oil content (%)
gca	9	E_1	39.75**	21.48**	401.33**	1.63**	94.66**	53.32**	68.69**	0.16**	46.36**	22.40**	61.37**	0.76**
		E_2	10.75**	23.78**	322.55**	1.88**	110.35**	43.8**	64.58**	0.19**	19.77**	59.91**	57.87**	1.29**
sca	45	E_1	3.07**	4.07**	8.15*	0.14**	2.49**	2.60**	1.51**	0.11**	53.25**	4.79**	31.00**	0.25**
		E_2	1.32**	14.18**	11.58**	0.15**	2.43*	2.43**	1.88**	0.12**	4.03**	56.87**	35.63**	0.49**
error	108	E1	0.40	0.90**	1.64	0.06	1.32	1.26	0.86	0.02	1.91	0.25	1.04	0.01
		E2	0.35	1.59	1.52	0.06	1.60	1.17	0.86	0.02	0.31	1.87	1.14	0.005
$\sigma^2 g$		E1	3.28	1.71	33.31	0.13	7.78	4.34	5.65	0.01	3.70	1.85	5.03	0.06
		E2	0.87	1.85	26.75	0.15	9.06	3.56	5.31	0.01	4.84	1.62	4.73	0.12
$\sigma^2 s$		E1	2.66	3.17	6.52	0.07	1.17	1.34	0.65	0.09	51.34	4.54	29.96	0.25
		E2	0.96	12.58	10.06	0.08	0.82	1.26	1.02	0.09	54.99	3.75	34.49	0.49
$\left(\frac{\sigma^2 g}{\sigma^2 s}\right)$		E1	1.23	0.54	5.11	1.75	6.63	3.23	8.72	0.13	0.072	0.406	0.168	0.253
		E2	0.90	0.15	2.66	1.83	10.98	2.83	5.20	0.15	0.09	0.43	0.14	0.22
$\left(\frac{\sigma^2 s}{\sigma^2 g}\right)^{0.5}$		E1	0.90	1.36	0.44	0.73	0.39	0.55	0.34	3	1.56	3.72	2.44	2.04
		E2	1.05	2.60	0.61	0.73	0.30	0.59	0.44	3	1.52	3.37	2.70	2.02

*, ** significant at 5% & 1% probability levels, respectively

Table 2: Estimates of specific combining ability effect for 12 characters in 10 x 10 diallel crosses of Indian mustard over Pooled and two environments (E_1 & E_2)

S. no	Characters	Days to 50% flowering		Days to maturity		Plant height		No. of primary branches	
	Crosses environments	E1	E2	E1	E2	E1	E2	E1	E2
1	T-151 X Jagrati	-0.55	0.86	1.68	1.49	-8.25***	-3.71**	0.26	-0.07
2	T-151 X NDYS 424	-1.05	-1.47*	-1.27	1.60	-0.88	-2.43*	-0.37	0.06
3	T-151 X NDYS 425	-1.91**	-2.30***	-0.99	-4.65***	6.06***	4.78***	0.71**	0.66**
4	T-151 X Ragini	2.25***	0.47	2.09*	4.71***	-4.87***	-0.99	-1.15***	-1.08***
5	T-151 X NDYS 427	2.28***	1.22*	-0.18	-1.62	6.69***	5.38***	0.30	0.12
6	T-151 X NDYS 116-1	0.59	0.14	0.09	5.21***	2.90*	1.02	0.23	0.07
7	T-151 X NDYS 08-01	1.67**	0.11	1.54	1.52	6.07***	4.40***	0.42	0.25
8	T-151 X NDYS 07-02	0.53	1.64**	1.18	5.63***	-4.74***	-0.32	-0.25	-0.22
9	T-151 X Pusa Gold	-0.30	2.03***	-2.93**	-3.54**	1.05	-0.95	-0.05	-0.12
10	Jagrati X NDYS 424	-1.53*	-2.25***	-0.32	0.60	0.51	-0.08	-0.14	0.45
11	Jagrati X NDYS 425	-2.39***	-1.41*	-1.38	-4.98***	1.22	-1.61	0.18	0.05
12	Jagrati X Ragini	1.45*	1.03	0.04	-0.29	-0.54	-3.41**	-0.12	-0.35
13	Jagrati X NDYS 427	2.14***	0.45	0.76	-0.95	1.10	-1.13	-0.10	0.05
14	Jagrati X NDYS 116-1	0.78	-0.30	-0.30	4.21***	0.53	2.13	-0.21	-0.41
15	Jagrati X NDYS 08-01	0.86	-0.33	-0.52	0.52	2.86*	3.48**	0.49*	0.45
16	Jagrati X NDYS 07-02	0.06	0.20	-2.55**	-2.04	1.45	4.12***	0.15	-0.12
17	Jagrati X Pusa Gold	0.56	1.59**	-1.99*	7.80***	1.02	-0.34	-0.55*	-0.17
18	NDYS 424 X NDYS 425	-0.22	0.92	2.34*	0.46	2.84*	2.90*	0.51*	0.74**
19	NDYS 424 X Ragini	2.61***	2.36***	3.43***	1.16	-0.09	1.41	0.22	-0.08
20	NDYS 424 X NDYS 427	2.31***	1.11*	1.48	1.16	0.59	-1.72	0.03	-0.05
21	NDYS 424 X NDYS 116-1	1.28*	0.70	0.76	-3.34**	-2.22	-2.88*	0.60*	0.58*
22	NDYS 424 X NDYS 08-01	1.36*	1.00	0.20	-1.04	-1.35	0.10	-0.34	-0.18
23	NDYS 424 X NDYS 07-02	-1.11	-0.80	-4.82***	-0.26	3.47**	4.04***	-0.02	-0.21
24	NDYS 424 X Pusa Gold	1.06	-0.41	-2.60**	3.57**	-1.56	0.45	-0.55*	-0.93***
25	NDYS 425 X Ragini	2.75***	-0.14	1.70	5.57***	0.85	-1.10	-0.26	-0.18
26	NDYS 425 X NDYS 427	1.78**	0.95	1.09	2.91*	-1.12	-1.92	-0.21	-0.09
27	NDYS 425 X NDYS 116-1	1.75**	1.20*	0.37	3.41**	-0.72	1.51	-0.42	-0.38
28	NDYS 425 X NDYS 08-01	1.17	1.84**	1.82*	1.38	-1.16	-0.37	-0.02	-0.16
29	NDYS 425 X NDYS 07-02	2.70***	0.03	0.12	6.49***	-2.37	-4.10***	-0.13	-0.63**
30	NDYS 425 X Pusa Gold	1.20*	0.09	-0.99	-3.68**	-1.93	-0.22	-0.09	0.10
31	Ragini X NDYS 427	-1.05	0.06	-1.49	0.27	1.72	11.98***	0.16	0.41
32	Ragini X NDYS 116-1	-2.41***	-1.36*	-1.21	3.77**	0.65	1.52	0.38	0.58*
33	Ragini X NDYS 08-01	-1.00	-0.39	-3.10***	-4.93***	2.11	1.03	0.25	0.27
34	Ragini X NDYS 07-02	-1.14	-0.53	0.20	-0.48	1.44	1.80	0.67**	0.56*
35	Ragini X Pusa Gold	-1.30*	-0.80	-0.57	-8.98***	-1.43	-5.05***	0.31	0.40
36	NDYS 427 X NDYS 116-1	-0.05	-1.28*	4.18***	-1.57	-1.58	-4.84***	-0.07	-0.15
37	NDYS 427 X NDYS 08-01	-1.97**	-0.97	-2.71**	-2.26	-5.42***	0.17	-0.37	-0.09
38	NDYS 427 X NDYS 07-02	-1.44*	-0.44	0.26	2.18	0.21	0.71	-0.08	-0.13
39	NDYS 427 X Pusa Gold	-1.94**	-0.72	-0.52	-0.65	-0.02	0.92	0.13	0.10
40	NDYS 116-1 X NDYS 08-01	2.00**	1.61**	-1.10	-2.09	-1.49	-1.19	-0.34	-0.35
41	NDYS 116-1 X NDYS 07-02	-0.47	1.14*	-0.80	-6.32***	1.51	2.48*	-0.15	0.14
42	NDYS 116-1 X Pusa Gold	-2.64***	-0.47	-2.24*	-1.15	1.04	2.12	0.12	0.05
43	NDYS 08-01 X NDYS 07-02	-0.72	-0.22	1.98*	0.66	-1.83	-2.44*	-0.09	0.03
44	NDYS 08-01 X Pusa Gold	-0.22	-1.16*	1.87*	-0.18	1.87	4.13***	0.36	0.18
45	NDYS 07-02 X Pusa Gold	0.64	-0.30	1.18	1.93	0.63	-1.22	0.49*	0.40

Table 2: Cont.....

S. no	Characters	Length of fruiting zone		No. of siliquae on main raceme		Seeds per siliqua		1000 seed weight	
	crosses environments	E1	E2	E1	E2	E1	E2	E1	E2
1	T-151 X Jagrati	-1.22	1.10	2.14*	-0.19	2.74**	2.80**	0.09	0.04
2	T-151 X NDYS 424	-0.21	2.15	-0.42	-0.42	0.29	-0.31	0.22	-0.01
3	T-151 X NDYS 425	-1.94	0.29	0.24	0.91	-0.64	4.69***	0.39**	0.48**
4	T-151 X Ragini	7.35**	-0.18	-0.87	-0.67	-0.71	-0.05	-0.51***	-0.66***
5	T-151 X NDYS 427	-0.04	-0.65	0.50	-1.06	-0.02	-0.17	0.06	-0.09
6	T-151 X NDYS 116-1	-0.91	-0.42	-1.35	0.21	-0.28	-0.36	-0.37**	-0.39**
7	T-151 X NDYS 08-01	0.35	2.57*	2.22*	0.72	-0.54	-0.77	0.67***	0.40**
8	T-151 X NDYS 07-02	0.13	1.18	-0.38	-0.46	-0.42	-1.08	0.21	0.43**
9	T-151 X Pusa Gold	-0.08	-0.68	0.09	1.53	-0.04	-1.07	-0.22	-0.44**
10	Jagrati X NDYS 424	0.13	0.64	0.61	0.15	-0.98	-0.80	-0.63***	-0.87***
11	Jagrati X NDYS 425	0.83	-0.60	0.20	-0.02	-0.34	-0.27	0.18	0.41**

Table 2: Cont.....

S. no	Characters	Length of fruiting zone		No. of siliquae on main raceme		Seeds per siliqua		1000 seed weight	
	crosses environments	E1	E2	E1	E2	E1	E2	E1	E2
12	Jagrati X Ragini	-0.56	-0.51	-1.41	-0.26	-0.95	-0.41	0.47***	0.28*
13	Jagrati X NDYS 427	0.20	-0.32	0.26	-0.12	0.21	-0.20	0.38**	0.01
14	Jagrati X NDYS 116-1	-0.67	2.60*	-0.72	0.48	-0.25	0.01	0.12	0.20
15	Jagrati X NDYS 08-01	2.13*	0.81	2.21*	1.46	0.16	-0.53	-0.06	0.03
16	Jagrati X NDYS 07-02	0.36	-1.07	-1.42	-1.76	0.44	-0.17	0.26*	0.27
17	Jagrati X Pusa Gold	-3.75***	-0.72	-0.88	-0.11	-0.44	-0.50	-0.10	0.36*
18	NDYS 424 X NDYS 425	1.22	1.25	1.21	1.85	1.11	0.09	-0.05	0.06
19	NDYS 424 X Ragini	-0.38	0.97	0.40	1.13	0.83	1.91*	0.00	-0.01
20	NDYS 424 X NDYS 427	-0.07	-6.61**	1.20	-0.59	-5.91***	-4.14***	-0.02	0.06
21	NDYS 424 X NDYS 116-1	-1.22	0.82	-0.81	-0.32	0.09	-0.26	0.20	0.59***
22	NDYS 424 X NDYS 08-01	-0.21	-0.69	0.48	-1.04	0.64	0.80	0.20	0.02
23	NDYS 424 X NDYS 07-02	-1.94	-0.93	-0.41	-0.20	0.76	0.72	0.50***	0.39**
24	NDYS 424 X Pusa Gold	2.39*	1.89	-1.97	-0.37	0.11	0.82	0.10	0.37*
25	NDYS 425 X Ragini	-0.56	-1.35	-1.57	0.07	-0.33	-2.22*	-0.44***	0.03
26	NDYS 425 X NDYS 427	0.08	1.09	0.09	-0.42	0.60	-0.27	0.16	0.25
27	NDYS 425 X NDYS 116-1	0.46	0.11	-0.55	-0.15	0.00	-0.12	-0.02	-0.33*
28	NDYS 425 X NDYS 08-01	-0.84	-1.46	1.01	-1.87	-0.12	-0.17	-0.12	-0.38**
29	NDYS 425 X NDYS 07-02	-0.37	1.05	-0.39	0.28	-0.17	-0.14	-0.47***	-0.70***
30	NDYS 425 X Pusa Gold	-0.53	-0.89	-0.05	-0.29	-0.22	-0.77	0.13	0.01
31	Ragini X NDYS 427	0.99	1.14	1.54	-1.41	1.86*	1.05	0.28*	0.38**
32	Ragini X NDYS 116-1	-1.44	-0.01	1.06	0.39	1.73*	1.66	0.66***	0.44**
33	Ragini X NDYS 08-01	0.52	0.98	0.55	-0.50	-1.73*	-2.04*	0.02	0.09
34	Ragini X NDYS 07-02	1.00	0.66	1.29	1.48	-0.68	-0.22	0.00	0.02
35	Ragini X Pusa Gold	1.16	1.17	0.70	0.98	-0.23	0.15	0.46***	-0.04
36	NDYS 427 X NDYS 116-1	1.00	1.08	-0.01	-0.62	-0.35	-1.66	-0.35**	-0.61***
37	NDYS 427 X NDYS 08-01	-0.27	0.24	-8.20***	8.19***	0.17	0.80	0.35**	0.34*
38	NDYS 427 X NDYS 07-02	-0.13	1.40	0.84	-0.56	0.75	0.93	-0.21	-0.06
39	NDYS 427 X Pusa Gold	0.34	0.30	1.08	-0.70	1.20	0.86	-0.18	-0.09
40	NDYS 116-1 X NDYS 08-01	0.83	-0.87	0.99	-1.14	-0.10	0.38	0.03	-0.20
41	NDYS 116-1 X NDYS 07-02	-0.13	-1.75	0.73	1.77	-0.95	0.10	-0.04	-0.15
42	NDYS 116-1 X Pusa Gold	-0.56	-0.27	0.27	-0.17	0.34	0.34	0.06	0.10
43	NDYS 08-01 X NDYS 07-02	-1.46	0.00	-0.68	-0.55	-0.10	0.26	-0.34**	-0.05
44	NDYS 08-01 X Pusa Gold	-0.72	-0.35	0.18	-0.60	0.98	1.37	-0.20	0.05
45	NDYS 07-02 X Pusa Gold	0.09	-1.11	0.51	-0.86	-0.33	-0.84	0.33**	0.06

Table 2: Cont.....

S. no	Characters	Seed yield per plant		Biological yield per plant		Harvest index		Oil content	
	crosses environments	E1	E2	E1	E2	E1	E2	E1	E2
1	T-151 X Jagrati	3.35***	1.74**	-6.88***	-12.25***	11.01***	14.80***	0.73***	-1.00***
2	T-151 X NDYS 424	-0.84	-0.88	-6.28***	-5.97***	1.97*	2.08*	0.88***	-0.67***
3	T-151 X NDYS 425	2.05***	4.44***	1.02	3.88**	3.16**	6.10***	-0.30***	-0.03
4	T-151 X Ragini	-3.21***	-3.26***	1.29	6.98***	-7.08***	-10.79***	0.10	-0.95***
5	T-151 X NDYS 427	0.34	-1.00	9.39***	7.67***	-3.99***	-6.64***	-0.23**	-0.76***
6	T-151 X NDYS 116-1	-1.65***	-1.46**	-7.19***	-1.27	-0.02	-3.24**	0.17*	0.55***
7	T-151 X NDYS 08-01	3.10***	0.98	1.79	3.57**	4.88***	-0.71	-0.43***	-0.33***
8	T-151 X NDYS 07-02	-1.19*	0.15	10.28***	3.60**	-7.18***	-2.41*	0.14*	0.60***
9	T-151 X Pusa Gold	-1.23*	-1.01	0.95	0.22	-3.27**	-3.10**	-0.41***	0.71***
10	Jagrati X NDYS 424	-3.23***	-1.21*	7.06***	3.97**	-8.60***	-4.83***	0.06	0.14*
11	Jagrati X NDYS 425	-0.24	1.63**	5.79***	11.32***	-3.91***	-3.56***	-0.15*	0.91***
12	Jagrati X Ragini	-0.12	-1.77**	4.72***	-4.53***	-3.09**	-1.34	0.34***	-0.84***
13	Jagrati X NDYS 427	1.30**	-1.22*	-1.51	-1.48	2.60**	-2.16*	-0.40***	0.17**
14	Jagrati X NDYS 116-1	-0.06	0.12	1.53	0.78	-1.23	-0.69	0.54***	-0.28***
15	Jagrati X NDYS 08-01	2.86***	0.98	7.46***	4.40**	1.01	-0.99	-0.46***	0.17**
16	Jagrati X NDYS 07-02	-0.75	-0.14	-2.00	2.67*	-0.57	-2.26*	-0.58***	-0.23***
17	Jagrati X Pusa Gold	-2.30***	1.45**	7.14***	9.08***	-7.89***	-3.08**	-0.13	-0.09
18	NDYS 424 X NDYS 425	1.67***	2.16***	7.94***	8.64***	-2.04*	-1.37	0.31***	0.87***
19	NDYS 424 X Ragini	0.15	0.28	-5.11***	-2.27	3.17**	1.70	0.05	-0.99***
20	NDYS 424 X NDYS 427	-3.03***	-2.13***	0.29	0.21	-5.92***	-4.54***	-0.35***	-0.40***
21	NDYS 424 X NDYS 116-1	1.95***	3.03***	-0.11	4.27**	3.27**	3.05**	0.37***	-0.05
22	NDYS 424 X NDYS 08-01	1.52**	-0.27	13.48***	11.88***	-4.25***	-5.90***	0.03	0.20**
23	NDYS 424 X NDYS 07-02	3.12***	1.46**	6.46***	0.61	0.81	1.69	0.20**	0.07

Table 2: Cont.....

S. no	Characters crosses Environments	Seed yield per plant E1	E2	Biological yield per plant E1	E2	Harvest index E1	E2	Oil content E1	E2
24	NDYS 424 X Pusa Gold	-1.93*	-3.25***	-13.56***	-4.85***	5.76***	-4.21***	-0.44***	0.77***
25	NDYS 425 X Ragini	-3.40***	-1.88***	2.95*	10.17***	-8.60***	-9.35***	0.12	-1.00***
26	NDYS 425 X NDYS 427	2.13***	2.03***	-0.48	-4.80***	3.56***	7.20***	-0.15*	-0.85***
27	NDYS 425 X NDYS 116-1	-1.38**	-2.50***	5.01***	1.14	-5.79***	-5.90***	0.30***	-0.04
28	NDYS 425 X NDYS 08-01	0.97*	-1.57**	-7.91***	-8.26***	7.82***	1.34	-0.07	0.26***
29	NDYS 425 X NDYS 07-02	-2.86***	-3.43***	-1.04	-2.56*	-5.21***	-5.89***	0.14*	0.70***
30	NDYS 425 X Pusa Gold	0.07	-0.23	-6.91***	-7.52***	5.21***	4.36***	-0.54***	-0.98***
31	Ragini X NDYS 427	1.75***	1.48**	5.96***	5.89***	-0.97	-1.52	0.12	0.87***
32	Ragini X NDYS 116-1	3.87***	4.59***	-5.67***	-3.05*	11.59***	10.60***	-0.53***	0.23***
33	Ragini X NDYS 08-01	-1.53**	-1.75**	9.35***	4.56***	-7.81***	-6.04***	0.27***	-0.32***
34	Ragini X NDYS 07-02	4.07***	2.29***	-1.85	-4.34**	8.71***	7.33***	1.13***	1.29***
35	Ragini X Pusa Gold	2.20***	0.76	-0.79	-1.60	4.54***	1.90	0.27***	1.13***
36	NDYS 427 X NDYS 116-1	-2.34***	-2.66***	14.37***	4.29**	-9.38***	-6.59***	0.71***	0.42***
37	NDYS 427 X NDYS 08-01	-4.15***	4.90***	-7.37***	-1.91	-4.92***	9.97***	0.35***	0.51***
38	NDYS 427 X NDYS 07-02	0.79	0.86	5.21***	9.26***	-2.06*	-4.05***	0.33***	0.07
39	NDYS 427 X Pusa Gold	1.59**	-0.53	1.28	6.15***	1.44	-5.04***	0.83***	0.13
40	NDYS 116-1 X NDYS 08-01	-0.42	-0.88	-4.53***	3.03*	1.16	-2.77**	-0.56***	-0.74***
41	NDYS 116-1 X NDYS 07-02	-1.84***	-0.38	-7.27***	11.81***	0.69	-5.56***	-0.36***	-0.72***
42	NDYS 116-1 X Pusa Gold	0.60	0.07	3.16*	5.49***	-1.15	-2.99**	-0.20**	-0.33***
43	NDYS 08-01 X NDYS 07-02	-2.03***	0.17	-8.43***	-4.11**	1.59	2.42*	-1.04***	-0.96***
44	NDYS 08-01 X Pusa Gold	1.05*	0.00	0.12	10.46***	1.73	-5.46***	0.60***	0.84***
45	NDYS 07-02 X Pusa Gold	2.10***	0.64	12.18***	3.11*	-3.70***	-1.39	0.30***	0.31***

Note-*, ** significant at 5% & 1% probability levels, respectively.

additive effect of good inbreds are highly responsible to heterozygosity. On the basis of specific combining ability effects, good specific cross combinations were NDYS 116-1 x Pusa Gold, Ragini õ NDYS 116-1, Jagrati x NDYS 425, YST-151 x NDYS 425, Jagrati x NDYS 424 for days to 50% flowering; NDYS 424 x NDYS 07-02, Ragini x NDYS 08-01, YST-151 x Pusa Gold, Ragini x Pusa Gold, NDYS 116-1 x NDYS 07-02, Jagrati x NDYS 425 for days to maturity; YST-151 x NDYS 427, YST-151 x NDYS 08-01, YST-151 x NDYS 425, Ragini x NDYS 427, YST-151 x NDYS 427, YST-151 x NDYS 425 for plant height; YST-151 x NDYS 425, Ragini x NDYS 07-02, NDYS 424 x NDYS 425, YST-151 x NDYS 425 for primary branches/plant; YST-151 x Ragini, Jagrati x NDYS 08-01, NDYS 424 x Pusa Gold, Jagrati x NDYS 116-1, YST-151 x NDYS 08-01, YST-151 x NDYS 424 for fruting zone length; YST-151 x NDYS 08-01, Jagrati x NDYS 08-01, YST-151 x Jagrati, NDYS 427 x NDYS 08-01, NDYS 424 x NDYS 425, NDYS 116-1 x NDYS 07-02 number of siliqua of main raceme; YST-151 x Jagrati, Ragini x NDYS 427, Ragini x NDYS 116-1, NDYS 424 x Ragini, Ragini x NDYS 116-1, NDYS 08-01 x Pusa Gold for seeds/siliqua; YST-151 x NDYS 08-01, Ragini x NDYS 116-1, NDYS 424 x NDYS 07-02, NDYS 424 x NDYS 116-1, YST-151 x NDYS 425, Ragini x NDYS 116-1 for 1000-seed weight; NDYS 427 x NDYS 116-1, NDYS 424 x NDYS 08-01, NDYS 07-02 x Pusa Gold, NDYS 424 x NDYS 08-01, NDYS 116-1 x NDYS 07-02, Jagrati x NDYS 425 for biological yield/plant; Ragini x NDYS 07-02, Ragini x NDYS 116-1, YST-151 x Jagrati, NDYS 427 x NDYS 08-01, Ragini x NDYS 116-1, YST-151 x NDYS 425 for seed yield/plant; Ragini x NDYS 116-1, YST-151 x Jagrati, Ragini x NDYS 07-02, YST-151 x Jagrati, Ragini x NDYS 116-1, NDYS 427 x NDYS 08-01 for harvest index and Ragini x NDYS 07-02, YST-151 x Jagrati, YST-151 x NDYS 424, Ragini x NDYS 07-02, Ragini x Pusa Gold, Jagrati x NDYS 425 were best specific combiners for oil content (Table 2). Since sca effect of the cross is an estimate for making selection of best cross combination, high specific combining ability denotes undoubtedly a high heterosis response; this however, does not mean high performance of the hybrids as well. The desired sca effects may not be of practical utility as the combinations which are compared with that of respective better parent (BP) and standard variety (SV). In pursuance to these objectives estimates of response relative to standard variety (NDYS-2) were computed for all the characters in different cross combinations.

REFERENCES

Anonymous 2010. Director's report presented at the 17th annual group meeting of rapeseed-mustard research workers, held at RVSKVV, Gwalior 1-3 Sept 2010.

Darrah, L. L. and Halluer, A. R. 1972. Genetic effects estimated from generation mean in four diallel sets of maize inbreds. *Crop Sci.* **12:** 615-621.

Griffing, B. 1956a. Concept of general and specific combining ability in relation to diallel crossing systems. *Aust. J. Biol. Sci.* **9:** 463-93.

Griffing, B. 1956b. A generalized treatment of the use of diallel crosses in quantitative inheritance. *Hered.* **10:** 31-50.

Katiyar, R. K., Chamola, R., Singh, H. B. and Tickoo, S. 2004. Heterosis and combining ability analysis for seed yield in yellow *sarson* (*B. campestris* (L.) var. yellow *sarson* prain). *Brassi.* **6(1/2):** 23-28.

Kumar, A. and Chauhan, J. S. 2005. Status, future thrust area of rapeseed-mustard in India. *Indian J. Agric. Sci.* **75(10):** 21-35.

Kumar, A., Tiwari R. and Kumar K. 2014. Exploitation of heterosis using cytoplasmic male sterility system in indian mustard [*brassica juncea* (l.) czern & coss.]. *The Ecoscan.* **6:** 163-167.

Kumar, C., Muralis, S. and Gupta, D. 2004. Heterosis studies in Indian mustard [*Brassica juncea* (L.) Czern and Coss.]. *Crucif. Newslet.* **24:** 59-60.

Kumar, M., Singh, K. P. and Singh, D. 2007. Genetic divergence analysis for seed yield, its parameters and oil content in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. *Crop Res.* **8(1):** 183-185.

Kumar, P., Lamba, A., Yadav, R. K., Singh, L. and Singh, M. 2013. Analysis of yield and its components based on heterosis and combining ability in indian mustard (*Brassica juncea* L. Czern and Coss). *The Bioscan.* **8(4):** 1497-1502.

Kumar, P., Yadava, T. P., Raj, L., Gupta, S. K. and Thakral, N. K. 1997. Combining ability and heterosis for oil content in toria (*Brassica campestris* L.). *Crucif. Newsle.* **19:** 87-88.

Malik, M. I., Noshin, Din, 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 [*Brassica juncea* (L.) Czern and Coss.]. *Asian J. Pl. Sci.* **2(14):** 1040-1046.

Parmar, M. B., Patel, K. M. and Prajapati, K. P. 2004. Assessment of genetic worth of parents and hybrids in Indian mustard, [*Brassica juncea* (L.) Czern and Coss.]. *J. Oilseeds Res.* **22(1):** 12-14.

Singh, A. K., Singh, Basudeo and Sachan, J. N. 2004. Diallel analysis for combining ability for yield and its components including oil content in Indian mustard. *J. Oilseeds Res.* **21(2):** 269-271.

Singh, D. and Mishra, V. K. 2001. Combining ability studies through fractional diallel in yellow *sarson. Ann. Pl. Soil Res.* **3(2):** 326-328.

Singh, D. and Mishra, V. K. 2001. Combining ability studies through fractional diallel in yellow *sarson. Ann. Pl. Soil Res.* **3(2):** 326-328.

Singh, K. H., Gupta, M. C. and Srivastava, K. K. 2003. Combining ability and heterosis in Indian mustard [*Brassica juncea* (L.) Czern and Coss.]. *J. Oilseeds Res.* **20(1):** 35-39.

Singh, M., Bashrat, A. H., Singh, L., Singh, B. and Dixit, R. K. 2008. Studies on combining ability for oil content, seed yield and its contributing characters in Indian mustard (*Brassica juncea* (L.) Czern and Coss.). *J. Prog. Res.* **3:** 174-150.

Tripathi, R. 2002. Genetic studies on intra and inter-specific hybridisation in *Brassica species*. Ph.D. thesis, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad.