Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 696-699
Received: 28-03-2019
Accepted: 30-04-2019

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Combining ability and heterosis for seed yield, its component traits and oil content in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]

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Abstract

Line x Tester mating design analysis was carried out in Indian mustard using 15 Indian mustard varieties/strains and 4 testers to study the combining ability and heterosis for yield and its components. General and specific combining ability (gca and sca) variances showed major contribution for all the thirteen characters studied. TERIWRBJ-32-1, RK-08-1, PARASMANI-2-10, SKM-0301, Maya, RGN-228 and RRN-631 among the lines and Kranti and NDYR-8 among testers in E1 (timely sown) whereas TERIWRBJ-32-1, JMM-08-1, TERIHOJ-48, Sahib-36 and LET–14-1 among the lines and Basanti among testers in E2 (late sown) condition were identified as superior donors for seed yield. Based on the magnitude of heterosis over BP, MP as well as SV, crosses *viz*., Pusa Karishma × NDRE-4, RK-08-1 × NDRE-4, PARASMANI-2-10 × NDRE-4 in E1 and RRN-631 × Basanti, TERIWRBJ-32-1 × Basanti, Sahib-36 × Basanti, Pusa Karishma ×NDRE-4 in E2 emerged as outstanding crosses for seed yield per plant. Best five cross combinations based on desirable SCA effects for seed yield were Pusa Karishma × NDRE -4 (6.88), PRKS-28 x Basanti, BPR-1205-5 × Basanti, TERIWRBJ-32-1 × NDYR–8 & LET-14-1 × Basanti in E1 and Pusa Karishma × NDRE-4, PRKS-28 × Kranti, NDRS-2001 × NDYR -8, TERIWRBJ -32-1 × Basanti & LET–14-1 × NDYR-8 in E2. Heterosis and *per se* performance may be used to select crosses for exploitation of heterosis in Indian mustard.

Keywords: Heterosis, Line x Tester mating, combining ability, Indian mustard [*Brassica juncea* (L.) Czern and Coss.]

Introduction

Rapeseed-mustard are major *rabi* oilseed crops of the northern India. Our country is the fourth largest oil economy in the world after the U.S., China and Brazil in terms of vegetable oils. Oilseed crops play an important role in agricultural economy of India. Our country is the fourth largest oil economy in the world after the U.S., China and Brazil in terms of vegetable oils. Annual commercial cultivation of 7 edible and 2 non-edible oilseed crops along with many other minor oilseed crops has been possible due to favourable agro ecological conditions. For breaking the present yield barrier and evolving varieties with high yield potential, it is desirable to combine the genes from genetically diverse parents. The success in identifying such parents mainly depends on the gene action that controls the trait under improvement, combining ability and genetic makeup. There are several techniques for evaluating the varieties or strains in terms of their combining ability and genetic makeup. Of these, diallel, partial diallel and line x tester techniques are in common use. In the present study, 15 lines, 4 testers and their 60 crosses were evaluated for combining ability and heterosis for seed yield, its components and oil content.

Materials and Methods

The material for present investigation was derived by crossing 15 strains/varieties of Indian mustard [*Brassica juncea* (L.) Czern & Coss.] With Kranti (T_1), Basanti (T_2), Narendra Ageti Rai-4 (T_3), and Narendra Swarna Rai-8 (T_4) in a line x tester mating design. A set of sixty crosses involving 15 lines and four testers was evaluated along with their 19 parents in Randomized Block Design with three replications at Research Farm of Department of Genetics & Plant Breeding, Narendra Deva University of Agriculture and Technology, Narendra Nagar, Faizabad (U.P.) under timely sown (E1) and late sown (E2) conditions. Observation were recorded for days to 50 per cent flowering, days to maturity, plant height (cm), primary branches per plant, secondary branches per plant, length of main raceme (cm), siliquae on main raceme, seeds per siliqua, 1000-seed weight (g), seed yield per plant (g), biological yield (g), harvest index (%) and oil content (%) .

The entries were sown in a single row plot of 5m length with inter and intra-row spacing of 45cm and 15cm, respectively. Combining ability analysis was done following standard procedure of Kempthorne (1957) [9]. Heterobeltiosis, relative heterosis and standard heterosis were estimated following the methods suggested by Hayes *et al.* (1955) [6]. Variety Kranti was used as the standard variety (check).

Results and Discussion

The analysis of variance for combining ability due to lines x testers showed highly significant differences for all the thirteen character in E1 & E2 except number of seeds per siliqua in E2 whereas, variance due to testers were also highly significant for days to 50 per cent flowering, days to maturity and plant height in E1 and days to 50 per cent flowering in E2 (Table 1). variance due to lines were also highly significant for days to 50 per cent flowering, plant height, number of primary branches per plant, length of main raceme, seed yield per plant and oil content in E1 and number of primary branches per plant and number of secondary branches per plant in E2. A fixable component of genetic variation is reflected by the contribution of lines and testers while non-fixable effects are shown by the lines x tester's component. In the present study, the relative contribution of lines x testers was found to be higher than those of lines and testers for all the characters studied. Similar observation was also recorded by Om Prakash (1991) [13].

A perusal of GCA effects revealed that among the lines, TERIWRBJ-32-1, RK-08-1, PARASMANI-2-10, SKM-0301, Maya, RGN–228 and RRN-631 and Kranti and NDYR-8 among testers in E1(timely sown) whereas TERIWRBJ-32-1, JMM-08-1, TERIHOJ-48, Sahib-36 and LET–14-1 among the lines and Basanti among testers in E2 (late sown) conditions were identified as superior donors for seed yield and its components with highly significant GCA effects for these traits (Table 2). The line BPR 1205-5 was found to be a good general combiner only for number of primary branches per plant and oil content in E1 and only for oil content in E2. Among the testers, NDRE-4 showed good general combining ability for days to 50 per cent flowering, days to maturity, number of primary branches per plant, biological yield and oil content in E1 and days to 50 per cent flowering, days to maturity and number of siliquae on main raceme in E2 while, Kranti tester was found good general combiner for plant height, length of main raceme, number siliquae on main raceme, seed yield per plant, 1000-seed weight and harvest index in E1 and plant height, length of main raceme and number of siliquae on main raceme in E2.

Ten crosses in E1 and 18 crosses in E2 for days to 50 per cent flowering (earliness), 16 crosses in E1 & 13 crosses in E2 for days to maturity (earliness), 27 crosses in E1 and 24 crosses in E2 for plant height, 11 crosses in E1 and 9 crosses in E2 for length of main raceme , 23 cross combinations in E1 and 8 crosses in E2 for number of primary branches per plant, 25 crosses in E1 and 22 crosses in E2 for number of secondary branches per plant, 26 cross combinations in E1 and 21 cross combinations in E2 for number of siliquae on main raceme, 9 good specific combiners in E1 and 4 good specific combiners in E2 for number of seeds per siliqua, 9 cross combinations in E1 and 4 cross combinations in E2 for 1000-seed weight, 18 cross combinations in E1 and 23 cross combinations in E2 for seed yield per plant, 26 good specific combiners in E1 and 24 good specific combiners in E2 for biological yield, 23 cross combinations in E1 and 27 cross combinations in E2 for harvest index and 11 cross combinations in E1 and 28 cross combinations in E2 for oil content displayed significant SCA effects. Best five cross combinations based on desirable SCA effects for seed yield were Pusa Karishma × NDRE -4, PRKS–28 x Basanti, BPR-1205-5 × Basanti, TERIWRBJ-32-1 × NDYR-8 & LET-14-1 × Basanti in E1 and Pusa Karishma × NDRE-4, PRKS–28 × Kranti, NDRS-2001 × NDYR -8, TERIWRBJ -32-1 × Basanti & LET–14-1 × NDYR-8 in E2.

Heterosis was calculated as per cent increase or decrease over better parent, mid parent and standard variety. A wide range of variation in the estimates of standard heterosis in positive and negative direction was observed for seed yield per plant (Table 3, 4, 5 & 6). In case of seed yield per plant, standard heterosis over better parent for seed yield ranged from -54.35 (BPR-1205-5 × NDYR-8) to 107.40 per cent (PARASMANI-2-10 × NDRE-4) in E1 and from -55.17 (Pusa Karishma × Kranti) to 63.27 per cent (TERIWRBJ-32-1 × Basanti) in E2 over BP, -50.59 (BPR -1205-5 × NDYR-8) to 85.12 per cent (PARASMANI-2-10 × NDRE-4) in E1 and -56.30 (Pusa Karishma × Kranti) to 67.44 per cent (Sahib-36 × Basanti) in E2 over MP and from -50.00 (Pusa Karishma × Kranti) to 38.10 per cent (TERIWRBJ-32-1 × NDYR-8) in E1 and -55.19 (Pusa Karishma × Kranti) to 37.88 per cent (TERIWRBJ-32-1 × Basanti) in E2 over SV (Kranti). Out of 60 F_1's studied , forty crosses in E1 and thirty-six crosses in E2 expressed desirable heterosis over BP, thirty-eight crosses in E1 and thirty-seven crosses in E2 over MP and thirty-one crosses in E1 and twenty-seven crosses in E2 over SV. Based on the magnitude of heterosis over BP, MP as well as SV, crosses *viz*., Pusa Karishma × NDRE-4, RK-08-1 × NDRE-4, PARASMANI-2-10 × NDRE-4 in E1 and RRN-631 × Basanti, TERIWRBJ-32-1 × Basanti, Sahib-36 × Basanti, Pusa Karishma ×NDRE-4 in E2 emerged as outstanding crosses for seed yield per plant. A wide range of heterosis for seed yield in Indian mustard has also been reported by different workers (Hirve and Tiwari, 1991[7]; Gupta *et al*., 1991 [8]; Ghosh and and Gulati, 1992 [3]; Patel *et al*., 1993 [12], Khulbe *et al*., 1998 [10]; Katiyar *et al*., 2000 [8]; Goswami *et al*., 2004 [4]; Chauhan *et al*., 2000 [2]; Batt *et al.*, 2005 [1]; Nair *et al*., 2005 [11] and Verma *et al*., 2000 [14]). The main points for utilization of heterosis at the commercial scale are extent of heterosis, preferably with more than 20 per cent standard heterosis and out-crossing mechanism ensuring hybrid seed production.

Table 1: Analysis of variance for combining ability for 13 characters in L x T mating design in Indian mustard

Characters d.f.	Source of variation							
	Lines		Testers		Lines x testers		Error	
	14		3		42		118	
	E1	E2	E1	E2	E1	E2	E1	E2
Days to 50% flowering	21.85*	42.05	485.06**	457.40**	8.83**	46.84**	1.41	2.13
Days to maturity	21.88	14.39	36.23*	30.60	12.52**	11.18**	1.80	2.35
Plant height	1479.84**	498.48	1216.83*	147.97	427.84**	427.68**	5.16	8.00
No. of primary branches per plant	2.34*	1.27*	1.82	1.05	0.94**	0.64**	0.23	0.27
No. of secondary branches per plant	18.24	25.35**	2.11	3.26	9.87**	4.80**	0.46	1.31

Length of main raceme (cm)	465.71	252.09	298.12	41.46	218.75**	154.79**	3.27	5.38
No. of siliquae on main raceme	351.53	64.19	359.45	36.16	190.04**	98.06**	6.20	6.05
No. of seeds per siliqua	1.53	0.39	1.36	1.09	1.68**	0.58	0.46	0.39
1000-seed weight (g)	0.97	0.76	0.56	0.73	0.63**	0.66**	0.15	0.28
Seed yield per plant (g)	41.82*	10.48	6.03	6.52	19.20**	10.15**	0.99	0.41
Biological yield	375.18	133.09	38.74	10.27	195.99**	188.80**	3.64	2.89
Harvest index (%)	52.02	137.31	33.60	44.70	109.72**	160.78**	7.06	3.11
Oil content (%)	5.42*	3.00	3.41	1.25	2.41**	3.74**	0.55	0.01

*, ** significant at 5 and 1 per cent probability levels, respectively.

Table 2: Best parents for different characters identified on the basis of their gca

Characters	Parents		Best Common Parents
	E1	E2	
Days to 50 per cent flowering	TERIWRBJ-32-1, NDRE-4, PRKS-28	TERIWRBJ-32-1, NDRE-4, RK-08-1	TERIWRBJ-32-1, NDRE-4
Days to maturity	BPR-1205-5, NDRS-2001, Sahib-36	TERIWRBJ-32-1, LET-14-1, NDRE-4	-
Plant height	NDRS-2001, Maya, PARASMANI-2-10	RGN-228, RRN-631, RK-08-1	-
No. of primary branches per plant	RRN-631, RK-08-1,PARASMANI-2-10	Maya, PRKS-28, SKM-0301	-
No. of secondary branches per plant	RRN-631, RK-08-1,PARASMANI-2-10	RGN-228, RRN-631, RK-08-1	RRN-631, RK-08-1
Length of main raceme	RGN-228, RRN-631, RK-08-1	Maya, RGN-228, RK-08-1	RGN-228, RK-08-1
Number of siliquae on main raceme	RGN-228, RRN-631, Sahib-36	RGN-228, RRN-631, Pusa Karishma	RGN-228, RRN-631
No. of seeds per siliquea	NDRS-2001, RGN-228	RGN-228, Basanti	RGN-228
1000 – seed weight (g)	NDRS-2001, LET-14-1	RRN-631, PARASMANI-2-10, Basanti	-
Seed yield per plant	PARASMANI-2-10, TERIWRBJ-32-1, RRN-631	TERIWRBJ-32-1, JMM-08-1, TERIHOJ-48	TERIWRBJ-32-1
Biological yield (g)	PARASMANI-2-10, RRN-631, RK-08-1	Maya, TERIHOJ-48, RGN-228	-
Harvest index (%)	Maya, PRKS-28, Sahib-36	Sahib-36, PARASMANI-2-10, PRKS-28	PRKS-28, Sahib-36
Oil content (%)	BPR-1205-5, TERIWRBJ-32-1, NDRS-2001	Sahib-36, RK-08-1, BPR-1205-5	BPR-1205-5

Table 3: Relationship of positive heterobeltiosis for seed yield with heterobeltiosis of other characters in E1

S. No.	Characters Crosses	Seed yield per plant (g)	No. of siliquae on main raceme	No. of seeds per siliqua	1000-seed weight (g)	Biological yield	Harvest index (%)
1.	PARASMANI-2-10 × NDRE-4	+	+	0	+	+	+
2.	Pusa Karishma ×NDRE-4	+	+	+	+	+	+
3.	RK-08-1 × NDRE-4	+	+	+	+	+	+
4.	Maya × NDRE-4	+	+	0	+	+	+
5.	TERIWRBJ-32-1 × NDRE-4	+	-	+	+	+	0
6.	SKM-0301 × NDRE-4	+	0	+	+	+	0
7.	PRKS-28 × NDRE-4	+	-	+	-	-	-
8.	RRN-631 × NDRE-4	+	+	+	+	+	-
9.	NDRS-2001 × NDRE-4	+	+	+	+	+	+
10.	TERIHOJ-48 × NDRE-4	+	-	+	+	+	+

Table 4: Relationship of positive heterobeltiosis for seed yield with standard heterosis of other characters in E2

S. No.	Characters Crosses	Seed yield per plant (g)	No. of siliquae on main raceme	No. of seeds per siliqua	1000-seed weight (g)	Biological yield	Harvest index (%)
1.	TERIWRBJ-32-1 × Basanti	+	+	-	+	+	+
2.	Pusa Karishma ×NDRE-4	+	+	+	+	+	+
3.	LET-14-1 × NDRE-4	+	+	+	+	+	+
4.	JMM-08-1 × NDRE-4	+	+	+	+	+	+
5.	Sahib-36 × Basanti	+	+	-	+	+	+
6.	TERIHOJ-48 × Basanti	+	+	0	+	+	0
7.	RK-08-1 × Basanti	+	+	-	+	+	+
8.	RRN-631 × Basanti	+	+	-	+	+	+
9.	TERIHOJ-48 × NDRE-4	+	+	0	+	+	+
10.	Maya × NDRE-4	+	+	+	+	+	-

Where,
+ = Significant and positive heterosis,
- = Significant and negative heterosis,
0 = Non-significant heterosis.

Table 5: Relationship of positive heterobeltiosis SV (Kranti) for seed yield with standard heterosis of other characters in E1

S. No.	Characters Crosses	Seed yield per plant (g)	No. of siliquae on main raceme	No. of seeds per siliqua	1000-seed weight (g)	Biological yield	Harvest index (%)
1.	TERIWRBJ-32-1 × NDYR-8	+	+	+	-	+	0
2.	PARASMANI-2-10 × Kranti	+	+	0	-	+	-
3.	PARASMANI-2-10 × NDRE-4	+	-	0	-	+	-
4.	PARASMANI-2-10 × NDYR-8	+	0	0	+	+	-
5.	Maya × NDYR-8	+	+	+	-	+	+
6.	Pusa Karishma ×NDRE-4	+	+	+	-	-	+
7.	PRKS-28 × Basanti	+	+	+	-	-	0
8.	RK-08-1 × Kranti	+	+	-	-	+	0
9.	RK-08-1 × NDRE-4	+	+	-	-	+	-
10.	RGN-228 × Kranti	+	+	+	-	+	+

Table 6: Relationship of positive heterobeltiosis SV (Kranti) for seed yield with heterobeltiosis of other characters in E2

S. No.	Characters Crosses	Seed yield per plant (g)	No. of siliquae on main raceme	No. of seeds per siliqua	1000-seed weight (g)	Biological yield	Harvest index (%)
1.	TERIWRBJ-32-1 × Basanti	+	+	+	+	+	0
2.	PRKS-28 × Kranti	+	-	+	0	+	+
3.	Sahib-36 × Basanti	+	-	+	+	+	+
4.	Maya × Kranti	+	+	+	+	+	-
5.	TERIHOJ-48 × Basanti	+	0	+	+	+	-
6.	Pusa Karishma ×NDRE-4	+	+	+	+	-	+
7.	LET-14-1 × NDYR-8	+	0	+	+	+	-
8.	TERIWRBJ-32-1 × NDYR-8	+	0	+	+	+	+
9.	RK-08-1 × Basanti	+	+	+	+	+	-
10.	RRN-631 × Basanti	+	-	+	+	+	-

Where,
+ = Significant and positive heterosis,
- = Significant and negative heterosis,
0 = Non-significant heterosis.

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