The Pharma Innovation Journal 2017; 6(9): 110-116

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating 2017: 5.03
TPI 2017; 6(9): 110-116

www.thepharmajournal.com
Received: 24-07-2017
Accepted: 25-08-2017

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Selection of best genotypes and cross combinations on the basis of combining ability effects and heterotic response in Indian mustard (*Brassica juncea* L. Czern & Coss)

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Abstract
Analysis of variance revealed that the genotypes were genetically-differ to each for all the characters. Combining ability analysis revealed that good general combiners were Varuna, RK-9109, Pusa Jagannath and Kanti for higher oil content and parents, RH-819, Pusa Bahar, Rohini and Kanti for high seed yield per plant. Out of 21 Crosses three Crosses namely were good specific combinations Pusa Jagannath x Pusa Bahar, Pusa Jagannath x Kanti and RH-819 x Kanti for seed yield per plant. as well as superior economic heterotic combinations Varuna x RK-9101, Varuna x Pusa Jagannath, Varuna x RH-819, Varuna x Rohini and RK-9101 x Pusa Jagannath for seed yield per plant.

Keywords: *Brassica*, combining ability (gca & sca), heterosis and Imdian mustard

1. Introduction
India annually produces 73.50 lakh tonnes of mustard seed in 2013-14 having a market share of 11 per cent. Rapeseed-mustard is the second most important edible oilseed crop in India after groundnut. It is one of the major sources of oil and oil meal in India. Mustard oil is traditionally the most important oil for the Northern, Central and Eastern parts of the country. Major mustard producing states in the country are Rajasthan, accounting more than 50% of its production followed by Uttar Pradesh, Haryana, Madhya Pradesh and Gujarat. The overall area under rapeseed-mustard has increased by 4.04 lakh ha to 71.30 lakh hac and production is expected to increase by 2.20 lakh tonnes to 73.50 lakh tonnes during 2014-15. Rapeseed and mustard is a major oil seed crop in Uttar Pradesh produces 1 lakh tones in 10.67 Lakh ha in 2014-15 which has 67.25 percent area with 80% production (FAOSTAT, 2014-15).

2. Materials & Methods
The present investigation was carried out at Oil Seed Research Farm, Kalyanpur of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, during rabi season 2013-15. The experiment was conducted in Randomized Block Design (RBD) with three replications. 7 parents/strains (Varuna, RK-9101, Pusa jagannath, RH-9801, Pusa bahar, Rohini & Kanti) were crossed in diallel mating design (excluding reciprocal crosses). 28 genotypes (21 F_1 + 7 parents) were evaluated for 13 characters viz. Days to flowering, Number of primary branches, Number of secondary branches, Days to maturity, Plant height, Number of siliquae per plant, Length of main raceme, Number of seeds per siliqua, Biological yield per plant (g), Harvest index (%), 1000-Seed weight (g), Oil content (%) and seed yield per plant (g). The parents and F_1s were growing in single row of five meter length spaced 45 cm apart. The distance of 15 cm between the plants in a row maintained by thinning. All the recommended agronomic practices were followed for raising the good crop. The components of variance in diallel cross were computed by the use of formula suggested by Hayman (1954a). The combining ability analysis was carried out by the procedure suggested by Griffing's (1956 b) Method 2, Model 1. Oil content was estimated with the help of NMR.

3. Results & Discussion
The analysis of variance for combining ability are presented in Table-1. The mean sum of square due to gca were highly significant for all the characters except biological yield. The mean sum of square due to sca was highly significant for all the characters except biological

yield and harvest index. The estimated variance of general combining ability (σ^2 gca) were higher than variance of specific combining ability (σ^2 sca) for all the characters except number of secondary branches per plant and whereas the estimated σ^2 sca were higher than of σ^2 gca for number of secondary branches per plant.

The estimated values of general combining ability effect are presented in Table-2. Significant negative gca effects were shown by the parents Pusa Jagannath and Kranti for days to flowering, for days to maturity significant negative gca effect were shown by the parent Kranti, for plant height significant negative gca effect were shown by parents Rohini and Kranti, for length of main raceme significant positive gca effect were shown by parents Varuna, RK-9101, Pusa Jagannath and RH-819, for number of primary branches per plant significant positive gca effect were shown by parents Pusa Jagannath and Rohini, for number of secondary branches per plant significant and positive gca effect were shown by parents RH-819 and Pusa Bahar, for number of siliquae per plant positive and significant gca effects were shown by Pusa Jagannath and Pusa Bahar, for number of seeds per siliqua positive and significant gca effects were shown by Pusa Jagannath, for biological yield per plant positive and significant gca effects were shown by RK 9101 and parent RK 9101, for harvest index positive and significant gca effects were shown by Varuna, Pusa Jagannath and RK 9101, Parents Varuna, RK-9109, Pusa Jagannath and Kanti were positive and significant and were the good general combiner for high oil content, for 1000-seed weight positive and significant gca effect were shown by parents RK-9109, Pusa Jagannath, Pusa Bahar and Rohini and all parents except RH-819, Pusa Bahar Rohini and Kranti. exhibited significant positive gca effect for seed yield per plant. Similar findings were also observed by Kumar *et al.* (2000) [14], Ghosh *et al.* (2002) [6], Goswami *et al.* (2005) [7], Monalisa *et al.* (2005) [17], Nair *et al.* (2005) [18], Lohia *et al.* (2008) [16], Singh *et al.* (2008b) [23], Nigam *et al.* (2009) [19], Gupta *et al.* (2010) [9], Dond *et al.* (2012) [4], Frasat *et al.* (2012), Arifullah *et al.* (2012) [1] and Dholu *et al.* (2014) [3].

The specific combining ability effects are presented in Table-3. For days to flowering the cross combination namely, Varuna x RH819 was shown highest and negative sca effect, for days to maturity the cross combinations namely, Varuna x RH819, Varuna x Pusa Bahar, Varuna x Kanti, Pusa Jagannath x Rohini, Pusa Jagannath x Pusa bahar and Pusa Bahar x Rohini were shown negative and highest sca effect, for plant height the cross combinations namely, Varuna x Pusa Bahar, RK9101 x Rohini and Pusa Jagannath x Kanti were shown highest and negative sca effects, for length of main raceme cross combinations Varuna x RH819, Varuna x Rohini, Varuna x Kanti, RK9101 x Pusa Bahar, RK-819 x Pusa Bahar and Jagannath x Kanti were shown significant positive sca effect, for number of primary branches per plant the cross combination Bahar x Kanti was shown positive and significant sca effect, for number of secondary branches per plant the cross combinations namely, RK-9101 x RH-819, Varuna x Pusa Bahar and Varuna x Rohini were shown positive and significant sca effect, the cross combinations Varuna x RK-9101, Varuna x Pusa Bahar, Varuna x Kanti, Pusa Jagannath x Pusa Bahar, Pusa Jagannath x Kanti and RH-819 x Kanti showed positive and significant sca effect for more number of siliquae per plant, positive and significant sca effects was found in only one cross combinations Pusa Bahar x Kanti for number of seeds per siliqua, for 1000-seed weight highest and positive significant sca effect found in cross combinations Varuna x Rk-9101, Varuna x Pusa Bahar, RK-9101 x RH-819, RK-9101 x Rohini, Pusa Jagannath x Kanti, RH-819 x Pusa Bahar and Pusa Bahar x Rohini, for oil content positive and significant sca effect were found in cross combinations Varuna x RK-9101, Varuna x Pusa Jagannath, Varuna x Kanti and RH-819 x Pusa Bahar and the cross combinations Varuna x RK-9101, Varuna x Pusa Jagannath, Varuna x RH-819, Varuna x Rohini and RK-9101 x Pusa Jagannath were found positive and significant sca effect for seed yield per plant. Similar findings were also observed by Kumar *et al.* (2000) [14], Ghosh *et al.* (2002) [6], Goswami *et al.* (2005) [7], Monalisa *et al.* (2005) [17], Nair *et al.* (2005) [18], Lohia *et al.* (2008) [16], Singh *et al.* (2008b) [23], Nigam *et al.* (2009) [19], Gupta *et al.* (2010) [9], Dond *et al.* (2012) [4], Frasat *et al.* (2012), Arifullah *et al.* (2012) [1], Dholu *et al.* (2014) [3].

The estimates of heterosis over standard or economic variety (Varuna) for thirteen characters were calculated and presented in Table-4. Out of 21 crosses the best five cross combinations viz., Varun x Pusa Jagannath, Varuna x Rohini, RK-9101 x Pusa Jagannath, Pusa Jagannath x RH-819 and Pusa Jagannath x Kanti showed negative and significant heterosis for days to 50% flowering. Top five crosses namely, Varuna x Pusa Jagannath, Varuna x Kanti, Pusa Jagannath x Kanti, RH-819 x Kanti and Pusa Bahar x Kanti were showed significant and desirable heterosis for days to maturity, the superior four cross combinations viz., Varuna x Rohini, RK-9101 x Rohini, Pusa Jagannath x Pusa Bahar and Pusa Bahar x Rohini were showed significant and negative heterosis for plant height, the best five crosses namely, Varuna x RK-9101, Varuna x Pusa Bahar, RK-9101 x Kanti, RH-819 x Kanti and Pusa Bahar x Kanti were showed negative and significant heterosis for length of main raceme, the crosses Varuna x Pusa Jagannath, Varuna x Pusa Bahar, RK-9101 x Rohini, Pusa Jagannath x Kanti and Pusa Bahar x Kanti were showed significant heterosis for number of siliquae per plant, the cross combinations viz., crosses RH-819 x Kanti, Pusa Bahar x Kanti, Pusa Bahar x Rohini and Rohini x Kanti showed high positive and significant heterosis for harvest index, the top three crosses namely, Varuna x RK-9101, Varuna x Pusa Jagannath and RK-9101 x Pusa Jagannath were showed positive significant heterosis for oil content, the cross combinations viz., RK-9101 x Pusa Jagannath, RK-9101 x Pusa Bahar, RK-9101 x Rohini, Pusa Jagannath x Pusa Bahar and Pusa Jagannath x Kanti were showed positive and significant heterosis for 1000-seed weight and the cross combinations viz., Varuna x RK-9101, Varuna x Pusa Jagannath, Varuna x RH-819 and Varuna x Rohini exhibited significant and positive heterosis over standard variety (Varuna) for seed yield per plant. Similar findings were also observed by Kakroo *et al.* (2000) [11], Katiyar *et al.* (2000) [13], Kant *et al.* (2001) [12], Ghosh *et al.* (2002) [6], Parmar *et al.* (2004) [20], Goswami *et al.* (2005) [7], Monalisa *et al.* (2005) [17], Prajapati *et al.* (2009) [21], Singh *et al.* (2009b) [22], Gupta *et al.* (2010) [9], Chauhan *et al.* (2011) [2], Dond *et al.* (2012) [4], Frasat *et al.* (2012), Lal *et al.* (2013) [15], Dholu *et al.* (2014) [3].

Table 1: ANOVA for combining ability and related statistics of 13 characters in a 7 x 7 parental diallel cross of F_1's in mustard.

Source of variation	d.f.	Days to flowering	No. of primary branches / plant	No. of secondary branches / plant	Day to Maturity	Plant hight (cm)	Length of main raceme (cm)
GCA	6	2.523***	2.624***	5.342***	140.48***	398.86***	562.53***
SCA	21	0.935**	0.673**	1.014	8.02***	37.87*	39.78***
Error	54	0.396	0.304	0.755	0.61	21.54	1.20
σ^2gca		0.24	0.26	0.51	15.54	41.92	62.37
σ^2sca		0.54	0.37	0.26	7.41	16.33	38.58

Table 1: Continue

Source of variation	d.f.	No. of Siliquae/ plant	No.of seed /siliqua	Biological yield/plant (g)	Harvest index (%)	1000-Seedweight (g)	Oil Content (%)	Seed yield /plant (g)
GCA	6	207.66***	2.79***	1.59	33.53***	0.09***	2.93***	11.36***
SCA	21	6.01	1.28**	1.20	0.21	0.07***	0.70***	1.42**
Error	54	4.27	0.49	0.72	1.48	0.00	0.03	0.74
σ^2gca		22.60	0.26	0.10	3.56	0.01	0.32	1.18
σ^2sca		1.74	0.78	0.48	-1.27	0.07	0.67	0.68
GPR		12.980	0.325	0.202	-2.810	0.148	0.418	1.731

*Significant at P = 0.05; **Significant at P = 0.01
GCA = General combining ability, SCA = Specific combining ability

Table 2: Estimates of gca effects for 7 parent alongwith their mean performance for 13 characters in F_1's of a diallel cross in Indian mustard.

Parents	Days to flowering		No. of primary branches/ plant		No.of secondary branchs/plant		Days to maturity		Plant height(cm)		Length of main raceme(cm)		No. of siliquae/plant	
	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean
Varuna	0.41*	74	0.14	10	0.26	23	0.43	128.67	3.23*	174.73	3.37**	75	-5.32**	354.67
RK-9101	-0.11	72.33	0.03	9	-0.37	22	2.03**	128	10.21**	195.53	2.96**	78.33	0.83	367
Pusa Jagannath	-0.56**	72.33	0.40*	10	0.22	22.33	0.25	124	2.43	174.73	9.93**	92	2.46**	372
RH-819	0.41*	74.33	0.21	10	0.63*	23.67	1.51**	127	2.09	180.33	6.74**	83.67	5.20	378.33
Pusa Bahar	0.19	73	-0.23	8	0.78**	24	3.17**	130	-1.38	171.67	-6.70**	62.67	4.64**	377.67
Rohini	0.52*	74	0.54**	10.67	0.00	22.33	1.29**	126	-9.24**	154.93	-4.07**	70	-0.40	367.33
Kanti	-0.85**	71	-1.08**	6	-1.52**	20	-8.68**	112	-7.33**	147.87	-12.22**	44.33	-7.40**	352.67
$\bar{X}_p$		73		10.67		22.48		125.10		171.4		72.29		367.10
SE (g_i) ±	0.72		0.63		0.99		0.90		5.31		1.26		2.36	
SE ($g_i - g_j$) ±	1.10		0.96		1.52		1.37		8.11		1.92		3.61	

Table 2: Continue

Parents	No.of seed /siliquae		Biological yield/plant (g)		Harvest Index (%)		1000-seed weight (g)		Oil content (%)		Seed yield / plant (g)	
	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean		Mean
Varuna	0.19	15	-0.17	82	2.69***	37.95	-0.12***	5.36	0.65***	40.21	1.87***	31.16
RK-9101	0.07	15	0.53*	83	0.77*	34.84	0.09***	5.23	0.44***	39.22	0.80**	28.88
Pusa Jagannath	0.56*	16	-0.76**	80	1.33***	36.19	0.07***	5.63	0.19***	38.42	0.22**	26.3
RH-819	0.52*	16	-0.10	81.33	0.18	33.92	-0.14***	5.33	-0.59***	37.33	0.17**	25.60
Pusa Bahar	-0.93***	11.67	0.24	81.67	-2.06***	29.63	0.03***	5.11	-0.66***	37.58	-1.15***	24.13
Rohini	0.19	15.33	0.31	81.67	0.01	33.61	0.11***	5.81	-0.53***	37.45	0.13**	26.77
Kanti	-0.59**	13	-0.06	81	-2.91***	27.70	-0.03***	5.43	0.50***	40.32	-1.43***	22.39
$\overline{X}_p$		14.57		81.52		33.41		5.41		38.65		26.46
SE (g_i) ±	0.80		0.97		1.39		0.00		0.19		0.98	
SE ($g_i - g_j$) ±	1.23		1.48		2.12		0.00		0.29		1.50	

*Significant at P = 0.05; **Significant at P = 0.01

Table 3: Estimates of sca effects and mean performance for 13 characters of 21 F_1's derived from a 7 parent dillel cross in Indian mustard.

Hybrid combination	Days to flowering		No. of Primary branches / plant		No. of secondary branches / plant		Days to maturity		Plant height (cm)		Length of main raceme (cm)		No. of siliquae /plant	
	sca effect	Mean	sca effect	Mean	sca effect	Mean	sca effect	Mean	sca effect	Mean	sca effect	Mean	sca effect	Mean
Varuna X Rk-9101	-0.13	72	-0.18	10	0.78	24.33	-0.72	123.67	-2.15	187.8	-2.08*	78.33	6.18**	371.33
Varuna X Pusa Jagannath	-0.69	71	0.45	11	0.85	25	-0.61	122	7.39	189.56	-4.05***	83.33	-0.45	366.33
Varuna X Rh-819	-1.65**	71	-0.03	10.33	-0.22	24.33	-2.20**	121.67	-1.69	180.13	7.81***		-1.19	368.33
Varuna X Pusa Bahar	0.57	73	0.08	10	0.30	25	-2.20**	123.33	9.54*	187.9	-1.08	69.67	1.69**	370.67
Varuna X Rohni	-1.09	71.67	-0.03	10.67	1.07	25	-1.98*	121.67	3.37	173.87	4.29***	77.67	2.06	366
Varuna X Kanti	0.28	71.67	0.27	9.33	-0.41	22	-4.02***	109.67	0.02	172.43	6.77***	72	0.40**	424
Rk-9101 X Pusa Jagannath	-1.17	70	-0.10	10.33	1.15	24.67	-0.54	123.67	-3.69	185.47	-1.97	85	1.06	374
Rk-9101 X Rh-819	-0.13	72	0.42	10.67	1.41	25.33	-1.13	124.33	0.56	189.37	-1.45	82.33	-0.34	375.33
Rk-9101 X Pusa Bahar	0.09	72	1.19*	11	-0.74	23.33	-0.80	126.33	-0.51	184.83	5.66***	76	-0.79	374.33
Rk-9101 X Rohini	-0.24	72	0.42	11	-0.63	22.67	0.76	126	-1.51	175.97	2.69*	75.67	1.92	372
Rk-9101 X Kanti	0.13	71	0.38	9.33	-0.11	21.67	-1.61*	113.67	10.10*	189.5	0.51	65.33	0.58	363.67
Pusa Jagannath X Rh-819	-0.69	71	0.38	11	-0.19	24.33	-0.69	123	-1.77	179.27	-3.75**	87	2.69	380
Pusa Jagannath X Pusa Bahar	-0.46	71	0.16	10.33	0.67	25.33	0.65	126	-3.04	174.53	1.03	68.33	1.25**	378
Pusa Jagannath X Rohini	0.20	72	0.05	11	0.44	24.33	0.54	124	2.09	171.8	1.73	81.67	-0.71	371
Pusa Jagannath X Kanti	-0.43	70	0.68	10	0.63	23	-2.50**	111	12.31**	183.93	10.88***	82.67	1.29**	366
Rh-819 X Pusa Bahar	-0.76	71.67	-0.32	9.67	0.93	26	0.39	127	-0.39	176.83	9.21***	83.33	0.51	380
Rh-819 X Rohini	0.24	73	-0.44	10.33	0.70	25	1.28	126	1.71	171.10	0.92	77.67	1.21	375.67
Rh-819 X Kanti	-0.39	71	0.86	10	-0.11	22.67	-1.76*	113	2.29	173.57	-4.94***	63.67	0.55**	368
Pusa Bahar X Rohini	-0.54	72	0.68	11	0.56	25	-0.06	126.33	-2.09	163.8	-16.97***	46.33	-1.56	372.33
Pusa Bahar X Kanti	-0.50	70.67	1.31*	10	0.74	23.67	-1.43	115	0.66	168.47	-1.82	53.33	1.44*	368.33
Rohini X Kanti	-0.83	70.67	0.19	9.67	0.52	22.67	-3.54***	111	2.62	162.57	-0.79	57	0.14	362
$\overline{X}$		71.44		10.32		24.10		123.67		178.22		74.21		373.68
SE (s_{ij}) ±	1.61		1.41		2.22		2.00		11.85		2.80		5.28	
SE ($s_{ij} - s_{ik}$) ±	2.39		2.09		3.30		2.97		17.61		4.16		7.84	

Table 3: Continue

Hybrid combination	No. of seeds /siliqua		Biological Yield/Plant (g)		Harvest Index (%)		1000-Seed Weight (g)		Oil content (%)		Seed yield / plant (g)	
	sca effect	Mean	sca effect	Mean	sca effect	Mean	sca effect	Mean	sca effect	Mean	sca effect	Mean
Varuna X Rk-9101	1.07	17	1.19	84.33	0.13	36.68	0.19***	5.80	0.97***	41.33	1.20**	30.93
Varuna X Pusa Jagannath	-0.07	16.33	0.16	82	0.09	37.20	-0.10***	5.50	0.81***	40.92	1.04**	30.2
Varuna X Rh-819	0.63	17	-0.18	82.33	0.08	36.03	-0.05***	5.35	-0.54**	38.79	1.02**	29.67
Varuna X Pusa Bahar		-1.26	0.16	83	-0.30	33.41	0.18***	5.73	-0.37*	38.9	-0.70**	27.72
Varuna X Rohni	0.96	17	0.08	83	0.25	36.04	-0.04***	5.59	-0.52**	38.88	1.24**	29.67
Varuna X Kanti	0.74	16	-0.55	82	0.77	33.63	-0.10***	5.40	0.39*	40.81	-0.25**	27.88
Rk-9101 X Pusa Jagannath	-0.30	16	1.12	83.67	-0.58	34.61	0.12***	5.93	1.62***	41.52	1.01**	28.95
Rk-9101 X Rh-819	0.74	17	-0.21	83	0.13	34.16	0.18***	5.78	-0.66***	38.46	0.03	28.35
Rk-9101 X Pusa Bahar	1.19	16	-0.21	83.33	0.05	31.85	0.41***	6.17	-0.38*	38.67	-0.14	27.2
Rk-9101 X Rohini	0.41	16.33	0.38	84	-0.27	33.60	0.18***	6.02	0.59***	39.77	-0.14	28.22
Rk-9101 X Kanti,	-0.15	15	-0.58	82.67	0.10	31.04	0.12***	5.83	-0.29	39.92	0.25	27.32
Pusa Jagannath X Rh-819	0.26	17	0.08	82	-0.07	34.53	-0.11***	5.47	0.59***	39.46	-0.11	27.63
Pusa Jagannath X Pusa Bahar	1.70*	17	1.08	83.33	-0.48	31.88	0.12***	5.87	0.14	38.95	1.12**	27.88
Pusa Jagannath X Rohini	-0.41	15	-0.32	82	0.41	34.83	-0.10***	5.72	-0.23	38.7	0.10	27.88
Pusa Jagannath X Kanti	0.37	16	0.38	82.33	-0.28	31.22	0.37***	6.06	-0.47**	39.49	1.88**	28.37
Rh-819 X Pusa Bahar	-0.26	15	0.08	83	0.00	31.21	0.18***	5.72	0.82***	38.85	0.52	26.9
Rh-819 X Rohini	-0.37	16	1.34	84.33	-0.56	32.72	0.00	5.62	1.71***	39.87	0.19	27.58
Rh-819 X Kanti	0.41	16	1.38	84	-0.50	29.85	-0.10***	5.38	-0.40*	38.78	2.63**	28.73
Pusa Bahar X Rohini	1.07	16	0.68	84	-0.23	30.81	0.18***	5.96	-0.07	38.02	1.14	27.55
Pusa Bahar X Kanti	1.85**	16	1.38	84.33	-0.38	27.73	0.12***	5.769	0.62***	39.73	0.58*	25.7
Rohini X Kanti	-0.26	15	1.31	84.33	-0.60	29.59	-0.10***	5.95	0.06	39.31	-0.19	25.95
$\overline{X}$		16.02		83.19		32.98		5.73		39.48		30.93
SE (S_{ij}) ±	1.79		2.16		3.10		0.00		0.43		2.19	
SE ($S_{ij} - S_{ik}$) ±	2.66		3.21		4.61		0.01		0.64		3.26	

Table 4: Estimates of heterosis over economic parent for 103characters in 21 F_1's derived from a 7 x 7 diallel cross in Indian mustard EP= Varuna

Hybrid combinations	Days to flowering	No. of Primary branches/ plant	No. of Secondary branches/ Plant	Days to maturity	Plant height (cm)	Length of main raceme (cm)	No. of iliquae /plant
	EH	EH	EH	EH	EH	EH	EH
Varuna X Rk-9101	-3.14*	-6.25	1.39	-4.87**	-3.95	-14.86**	-1.85*
Varuna X Pusa Jagannath	-4.48**	3.12	4.17	-6.15**	-3.05	-9.42**	-3.17**
Varuna X Rh-819	-4.48**	-3.13	1.39	-6.41**	-7.88*	0.00	-2.64**
Varuna X Pusa Bahar	-1.79	-6.25	4.17	-5.13**	-3.90	-24.28**	-2.03*
Varuna X Rohni	-3.59**	0.00	4.17	-6.41**	-11.08**	-15.58**	-3.26**
Varuna X Kanti	-3.59**	-12.50	-8.33	-15.64**	-11.81**	-21.74**	-5.55**
Rk-9101 X Pusa Jagannath	-5.83**	-3.13	2.78	-4.87**	-5.15	-7.61**	-1.15
Rk-9101 X Rh-819	-3.14*	0.00	5.56	-4.36**	-3.15	-10.51**	-0.79
Rk-9101 X Pusa Bahar	-3.14*	3.12	-2.78	-2.82**	-5.47	-17.39**	-1.06
Rk-9101 X Rohini	-3.14*	3.12	-5.56	-3.08**	-10.01**	-17.75**	-1.67*

Rk-9101 X Kanti	-4.48**	-12.50	-9.72	-12.56**	-3.09	-28.99**	-3.88**
Pusa Jagannath X Rh-819	-4.48**	3.12	1.39	-5.38**	-8.32*	-5.43**	0.44
Pusa Jagannath X Pusa Bahar	-4.48**	-3.13	5.56	-3.08**	-10.74**	-14.86**	-0.09
Pusa Jagannath X Rohini	-3.14*	3.12	1.39	-4.62**	-12.14**	-11.23**	-1.94*
Pusa Jagannath X Kanti	-5.83**	-6.25	-4.17	-14.62**	-5.93	-10.14**	-3.26**
Rh-819 X Pusa Bahar	-3.59**	-9.38	8.33	-2.31**	-9.56**	-9.42**	0.44
Rh-819 X Rohini	-1.79	-3.13	4.17	-3.08**	-12.51**	-15.58**	-0.70
Rh-819 X Kanti	-4.48**	-6.25	-5.56	-13.08**	-11.23**	-30.80**	-2.73**
Pusa Bahar X Rohini	-3.14*	3.12	4.17	-2.82**	-16.23**	-49.64**	-1.59
Pusa Bahar X Kanti	-4.93**	-6.25	-1.39	-11.54**	-13.84**	-42.03**	-2.64**
Rohini X Kanti	-4.93**	-9.38	-5.56	-14.62**	-16.86**	-38.04**	-4.32**
Se(Ep)=	0.89	0.78	1.23	1.11	6.56	1.55	2.92

Table 4: Continue - EP = Varuna

Hybrid combinations	No.of seed /siliquae	Biological Yield/Plant (g)	Harvest Index(%)	1000-Seed Weight(g)	Oil content(%)	Seed yield / plant(g)
	EH	EH	EH	EH	EH	EH
Varuna X Rk-9101	6.25	1.61	-3.36	-0.17**	2.50**	4.00**
Varuna X Pusa Jagannath	2.08	-1.20	-1.99	-5.34**	1.49*	3.90**
Varuna X Rh-819	6.25	-0.80	-5.06	-8.03**	-3.80**	3.45**
Varuna X Pusa Bahar	-14.58*	0.00	-11.96*	-1.26**	-3.53**	-11.04**
Varuna X Rohni	6.25	0.00	-5.03	-3.79**	-3.59**	2.90**
Varuna X Kanti	0.00	-1.20	-11.39*	-7.11**	1.21	-10.51**
Rk-9101 X Pusa Jagannath	0.00	0.80	-8.82	2.07**	2.97**	2.98**
Rk-9101 X Rh-819	6.25	0.00	-9.99*	-0.52**	-4.62**	-9.01*
Rk-9101 X Pusa Bahar	0.00	0.40	-16.09**	6.20**	-4.10**	-12.70**
Rk-9101 X Rohini	2.08	1.20	-11.46*	3.61**	-1.38*	-9.44*
Rk-9101 X Kanti	-6.25	-0.40	-18.21**	0.34**	-0.99	-12.32**
Pusa Jagannath X Rh-819	6.25	-1.20	-9.03	-5.85**	-2.13**	-11.31**
Pusa Jagannath X Pusa Bahar	6.25	0.40	-16.01**	1.03**	-3.41**	-10.51**
Pusa Jagannath X Rohini	0.00	-1.20	-8.22	-1.55**	-4.03**	-10.51**
Pusa Jagannath X Kanti	0.00	-0.80	-17.73**	4.30**	-2.07**	-8.95*
Rh-819 X Pusa Bahar	-6.25	0.00	-17.78**	-1.55**	-3.66**	-13.66**
Rh-819x Rohini	0.00	1.61	-13.80**	-3.27**	-1.13	-11.47**
Rh-819 X Kanti	0.00	1.20	-21.35**	-7.40**	-3.82**	-7.78
Pusa Bahar X Rohini	0.00	1.20	-18.81**	2.58**	-5.72**	-11.58**
Pusa Bahar X Kanti	0.00	1.61	-26.94**	-0.69**	-1.46**	-17.51**
Rohini X Kanti	-6.25	1.61	-22.04**	-3.27**	-2.52**	-16.71**
Se(Ep)=	0.99	1.19	1.72	0.00	023	1.21

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