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HETEROSIS STUDIES FOR SOME FATTY ACIDS COMPOSITION OF INDIAN MUSTARD (*BRASSICA JUNCEA* L.)

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ABSTRACT

Mid-parent and better-parent heterosis was estimated in *Brassica juncea* L. lines by using 8 x 8 full diallel. Randomized complete block design (RCBD) with two replications were used for 56 F_1 hybrids and their parent. Out of 56 crosses, 34 crosses showed significant heterosis for oil %age. Significant positive heterobeltiosis was recorded in 26 crosses. For glucosinolate content out of 56 F_1s significant negative heterosis was monitored for 16 crosses. Significant negative heterobeltiosis was observed in 7 crosses. In case of erucic acid, 32 crosses confined significantly negative heterosis. On the other hand 21 crosses exhibited significant negative heterobeltiosis. For protein, 32 crosses showed significant heterosis. Significant positive heterobeltiosis recorded for 27 crosses. In case of oleic acid content, 49 crosses revealed positive values, with significant positive heterosis in 17 crosses. Data for heterobeltiosis showed that positive values were recorded for 41 crosses. Significant positive heterobeltiosis was detected for 8 crosses. Data regarding linolenic acid demonstrated that out of 56 crosses, 32 crosses contained significantly negative heterosis. Heterobeltiosis values for linolenic acid content showed that, negative values were detected for 22 crosses. Significant negative heterobeltiosis was recorded for 11 crosses.

Key words: Heterosis, Mid-parent, Better-parent, Mustard, *Brassica juncea* L, Fatty acids.

INTRODUCTION

In the family of Brassicacea rapeseed and mustard has a prominent position. Brassica species has multiple uses like vegetable, edible oil, fodder, condiment and also used for the fertility of land as green manure. As vegetable oil containing unsaturated fatty acids, so the importance of these crops as vegetable oil increased with every passing day. Vegetable Oil is among the few valuable agricultural commodities of any country, and its demand increases as the world population increase (Arifullah, 2011). Indian mustard (*Brassica juncea* L. Czern and Coss) is the second largest oilseed crop in Pakistan after cotton seed oil. It accounts for nearly 30% of the total oilseeds and 27% to edible oil pool of the country (Saeed *et al*. 2013). Although Pakistan is agrobased country, but in the country these is a large gap between our local edible production and our consumption. On average the local production of edible oil is only 22% and the remaining 78% is being imported from abroad by expending huge foreign exchange (Anonymous, 2013). Fatty acids profile play key role in the use of brassica oil by human beings. Vegetable oil seed having higher proportion of 16 and 18 carbons unsaturated fatty acids, particularly monounsaturated fatty acids (MUFAs), are considered suitable for use as edible oil (Simopoulos, 2008; Ramos *et al*. 2009; Priyamedha *et. al.* 2014). Indian mustard seed contains 35-45% oil having 92-98% triacylglycerol of fatty acids (C16-C22). It contains lowest saturated fat and possesses more proportion of linoleic (C18:2) and linolenic (C18:3) acid which are not synthesized by the human body. Linolenic acid is an essential dietary fatty acid, but undesirable in edible oil because of being prone to auto-oxidation resulting in off-flavours and reduced shelf life of the oil. Erucic acid (C22:1) comprises nearly 50% of total fatty acid which is undesirable for human consumption as they are reported to impair myocardial conductance and increase blood cholesterol. Therefore, it is dire need to reduce glucosinolate and erucic acids in the seed oil of *B. juncea* (Priyamedha *et al.* 2014). By product of brassica species which remain after oil extraction is a valuable commodity obtained having sufficient amount of essential amino acids and protein (approximately 40 %). They also contain some minerals like Ca, Mg and P and vitamin B4 and E as well. Presently, Indian mustard is not only used for livestock feeding, but also play an important role as raw material for the production of various industrial products (Bala and Singh, 2012). However, in comparison to other popular sources such as soybean, it contains high amount of glucosinolate, which lessen its feed value (Wanasundara, 2011). The amelioration of nutritional qualities of seed meal of Indian mustard by reducing the amount of glucosinolate, therefore, can be of high economic value. Therefore high amount of erucic acid and glucosinolate, are the major hurdle in the production double of zero canola types *B. juncea* varieties. Although international efforts had been started in the 1950s, for the developing rapeseed-mustard strains with double low characteristics, but these efforts was restricted to *B. napus* and not a single variety has been developed till date in Indian mustard, possessing double low traits (Priyamedha *et al.* 2014). To boost quality and quatitity traits in Brassica and other crops heterosis is the most appropriate method (Hassan *et al*. 2006). Through heterosis we can increase our production in short time by utilization of less input (Pal and Sikka, 1956).

Therefore, in the present study an effort was made to identify promising *B. jucea* genotypes from the available gene pool to be used as donor parent for the production of low erucic acid and glucosinolate and high yield oil %age canola lines.

MATERIALS AND METHODS

An experiment was conducted in which eight *Brassica juncea* L. lines were crossed in full diallel fashion. Seeds of these lines were collected from Crop Breeding Division of Nuclear Institute for Food and Agriculture (NIFA), Tarnab-Peshawar-Pakistan. These lines were designated as NUT009, NUM103, NUM105, NUM113, NUM117, NUM120, NUM123 and NUM124.

In Rabi season, all the eight lines were sown at NWFP Agricultural University, Peshawar. Research Farm. Sowing was done in lines with the help of seed drill, with row length of 4 m having row to row distance of one meter and plant to plant 30 cm. In order to keep proper distance between blocks, two meter distance was kept between blocks. Each line were assigned four rows, and these were grown under natural condition i.e. neither fertilizer and nor pesticide was applied. When the lines to budding stage ten best (healthy) plants row^{-1} from each line was selected for crossing. When these selected plants reached the budding stage, five inflorescences from each selected plant were emasculated and bagged. The following morning, emasculated flowers were pollinated with pollen collected from the desired male parents. The hybridized material was properly labeled and tagged. Seeds of individual cross were collected at maturity.

During next growing season, the F_1 hybrids along with parental lines were sown in RCBD with two replications to compare the performance of F_1s with their respective parents. After maturity seed were harvested and analyzed for oil, protein, oleic acid, linolenic acid, glucosinolates and erucic acid through Nuclear Infra Red Spectroscopy (NIRS) in NIFA Peshawar.

Statistical Analysis: After compilation of the data the percent increase (+) or decrease (-) of F_1 cross over mid parents as well as better parent was calculated to check the heterosis for all the studied parameters. Matzingar *et al.* (1962) method was used to check heterosis for mid parent and better parent (heterobeltiosis).

$$\text{Mid-parent Heterosis (\%)} = \frac{(F_1 - MP)}{MP} \times 100$$

$$\text{Better-parent Heterosis (\%)} = \frac{(F_1 - BP)}{BP} \times 100$$

Where,

MP = mid parental value of the particular F_1 cross ($P_1 + P_1/2$)

BP = better parent value in the particular F_1 cross

The difference of F_1 mean from their respective mid parent and better value was evaluated by using a t-test acceding to Wynne *et al*. (1970).

$$\frac{F1_{ij} - MP_{ij}}{\sqrt{\frac{3}{8}}\ \sigma^2}$$

Where, F_{ijk} = the mean pf the *ij*th F_1 cross,

Mp_{ij} = mid parent value of *ij*th cross, and

σ^2_c = estimate of error variance.

RESULTS

Oil (% age): The main objective of Brassica is to produce oil, therefore, Brassica lines containing more oil contents are desirable, so positive heterosis and heterobeltiosis is useful. Heterotic values for oil% showed that out of 56 crosses, 37 crosses had positive heterosis where data ranged from 0.01% to 42.60%. Among these crosses, 34 crosses showed significant heterosis with maximum value (42.60%) being attained by the cross NUM123xNUM113. Data regarding heterobeltiosis showed that positive values were noticed in 30 crosses where figures ranged from 0.00% to 9.52%. Significant positive heterobeltiosis was recorded in 26 crosses of which cross NUM124xNUM120 showed maximum (9.52) values (Table 1).

Glucosinolate (% age): Glucosinolate is one of the major unwanted components of Brassica seed meal therefore for getting improved brassica lines negative or lower levels of heterosis and heterobeltiosis for glucosinolate is preferred. Data regarding glucosinolate content showed that out of 56 crosses, 16 crosses had negative values where figures ranged from -0.01% to -26.46%. Significant negative heterosis was monitored for 16 crosses where the maximum negative value (-26.46%) was recorded in cross NUM113xNUM105. However, data regarding heterobeltiosis showed that out of 56 crosses, negative values were recorded for 7 crosses where data ranged from -0.01% to -16.67%. Significant negative heterobeltiosis was detected for 7 crosses with the maximum negative values (-16.67%) being found in cross NUM113xNUM105 (Table 1).

Table 1. Estimates of heterosis (Ht. %) and Heterobeltiosis (Hbt. %) for oil, glucosinolate and Erucic acid content in *Brassica Juncea.*

	Oil (%)		Glucosinolate (%)		Erucic acid (%)	
Crosses	**Ht%**	**Hbt%**	**Ht%**	**Hbt%**	**Ht%**	**Hbt%**
NUM103XNUM009	-1.44*	-3.96**	13.10**	15.98**	-33.94*	5.88**
NUM103XNUM124	-4.53**	-4.86**	11.96**	16.73**	4.86**	90.44**
NUM103XNUM113	-3.30**	-5.56**	13.84**	1.15**	-34.83**	-14.71**
NUM103XNUM123	-1.45*	-4.66**	-6.47**	-2.47**	40.44**	13.35**
NUM103XNUM117	-0.68	-2.68**	-9.12**	11.12**	-27.54**	62.50**
NUM103XNUM105	0.12	-4.20**	-1.52**	8.75**	-29.06**	22.06**
NUM103XNUM120	-8.51**	-9.75**	0.97**	25.95**	-5.26**	32.35**
NUM009XNUM103	0.01	-0.01*	0.15**	0.18**	0.31**	1.10**
NUM009XNUM124	-3.93**	-6.71**	30.99**	18.98**	-41.64**	-36.00**
NUM009XNUM113	-3.15**	-7.78**	2.98**	5.19**	-46.54**	-36.82**
NUM009XNUM123	-0.25	-0.98**	17.63**	29.67**	-10.75**	-8.67**
NUM009XNUM117	-1.64*	-6.04**	11.46**	22.88**	-70.28**	-61.67**
NUM009X105NUM	3.38**	1.47*	13.65**	31.87**	31.33**	38.33**
NUM009XNUM120	-9.43**	-12.93**	12.51**	24.48**	-6.62**	4.10**
NUM124XNUM103	0.13**	0.13**	0.19**	-0.08**	-0.34**	0.21**
NUM124XNUM009	0.12**	0.08**	-0.08**	0.20**	-0.36**	-0.30**
NUM124XNUM113	-2.04*	-4.00**	-6.39**	-5.38**	-28.37**	-5.91**
NUM124XNUM123	7.56**	3.70**	-6.55**	1.86**	-9.52**	-3.18**
NUM124XNUM117	8.76**	6.94**	11.04**	21.04**	6.97**	24.30**
NUM124X105NUM	7.52**	2.55**	1.54**	16.44**	-38.55**	-36.14**
NUM124XNUM120	10.65**	9.52**	-0.18**	9.20**	33.89**	65.16**
NUM113XNUM103	0.02**	0.00	0.05**	0.05**	0.90**	1.49**
NUM113XNUM009	0.08**	0.02**	0.11**	0.14**	-0.15**	0.00**
NUM113XNUM124	0.07**	0.04**	0.17**	0.18**	0.63**	1.14**
NUM113XNUM123	7.17**	1.33*	2.04**	9.96**	-35.96**	-22.27**
NUM113XNUM117	-3.46**	-3.78**	-3.11**	4.41**	-59.08**	-35.45**
NUM113XNUM105	10.69**	3.56**	-26.46**	-16.67**	8.70**	36.36**
NUM113XNUM120	-4.15**	-5.11**	9.39**	18.30**	-53.45**	-50.91**
NUM123XNUM103	0.06**	0.03*	-0.04**	0.03**	-0.62**	-0.37**
NUM123XNUM009	0.05**	0.04**	0.17**	0.29**	-0.32**	-0.30**
NUM123XNUM124	0.04**	0.00	0.11**	0.21**	-0.12**	-0.05**
NUM123XNUM113	42.60	-0.05**	0.07**	0.15**	28.20**	0.28**
NUM123XNUM117	4.72**	-0.67	-1.41**	-1.41**	-20.56**	-0.32**
NUM123XNUM105	6.18**	4.99**	8.78**	14.01**	-17.96**	57.49**
NUM123XNUM120	0.71	-3.85**	1.40**	1.74**	51.61**	73.36**
NUM117XNUM103	0.03**	0.01	-0.04**	0.03**	0.58**	2.54**
NUM117XNUM009	0.11**	0.06**	0.17**	0.29**	-0.27**	-0.06**
NUM117XNUM124	0.11**	-0.04**	0.11**	0.21**	-0.23**	-0.10**
NUM117XNUM113	0.05**	0.04**	0.07**	0.15**	0.12**	0.76**
NUM117XNUM123	0.08**	0.02*	-0.01**	-0.01**	0.02**	0.28**
NUM117XNUM105	5.84**	-0.67	8.78**	14.01**	14.14**	38.55**
NUM117XNUM120	-16.67**	-17.23**	1.40**	1.74**	-52.09**	-29.51**
NUM105XNUM103	0.06**	0.01*	0.08**	0.22**	0.47**	1.54**
NUM105XNUM009	0.11**	0.09**	0.03**	0.19**	0.40**	0.47**
NUM105XNUM124	0.05**	0.00	0.05**	0.20**	0.20**	0.24**
NUM105XNUM113	0.09**	0.02*	0.01**	0.14**	-0.24**	-0.04**
NUM105XNUM123	0.07**	0.05**	0.05**	0.10**	0.03**	7.51**
NUM105XNUM117	-0.06**	-0.12**	0.02**	0.07**	-0.51**	-0.41**
NUM105XNUM120	-3.72**	-9.07**	-1.18**	3.21**	-3.47**	13.93**
NUM120XNUM103	0.05**	0.04**	-0.02**	0.06**	0.33**	0.85**
NUM120XNUM009	0.04**	0.09*	0.10**	0.22**	-0.04**	0.07**

NUM120XNUM124	-0.01**	0.00**	0.11**	0.21**	-0.43**	-0.30**
NUM120XNUM113	-0.06**	0.02**	0.05**	0.14**	0.10**	0.16**
NUM120XNUM123	0.01	0.05**	0.14**	0.14**	-0.02**	18.13**
NUM120XNUM117	0.10**	0.09**	-0.03**	-0.02**	0.13**	101.88**
NUM120XNUM105	0.04**	-0.02*	0.05**	0.10**	0.06**	38.13**

* P≤ 0.05 **P≤0.01

Erucic acid (% age): Erucic acid content of Brassica oil is one of the major undesirable components, which make this oil unsuitable for human consumption. Therefore negative heterosis and heterobeltiosis is desirable for erucic acid. Data regarding erucic acid content presented in Table 1, demonstrated that out of 56 crosses, 32 crosses contained significantly negative heterosis where data ranged from -0.02% to -70.28%. The maximum negative value (-70.28%) was recorded in cross NUM009xNUM117. Heterobeltiosis values for erucic acid content showed that out of 56 crosses, negative values were detected for 21 crosses. The data for these crosses ranged from -0.04% to -61.67 %. Significant negative heterobeltiosis was recorded for 21 crosses where the maximum negative values (-61.67) was found in cross NUM009xNUM117 (Table 1).

Protein (% age): The main objective of Brassica is to produce oil, therefore, Brassica lines containing lower amount of protein are desirable, because there is negative relation between oil and protein. So negative heterosis and heterobeltiosis is useful for this parameter. Heterosis values for protein % (Table 2) showed that out of 56 crosses, 52 crosses had negative heterosis where data ranged from -0.01% to -21.53%. Among these crosses, 32 crosses showed significant heterosis with maximum value (-21.53%) being attained by the cross NUM123xNUM113. Data regarding heterobeltiosis showed that negative values were noticed in 40 crosses where figures ranged from -0.01% to -19.29%. Significant negative heterobeltiosis was recorded in 27 crosses of which cross NUM113xNUM123 showed maximum (-19.29) values (Table 2).

Table 2. Estimates of heterosis (Ht. %) and Heterobeltiosis (Hbt. %) for protein, oleic and Linolenic acid content in *Brassica Juncea.*

	Protein (%)		**Oleic Acid (%)**		**Linolenic acid (%)**	
Crosses	**Ht%**	**Hbt%**	**Ht%**	**Hbt%**	**Ht%**	**Hbt%**
NUM103XNUM009	-6.95**	-6.45**	3.43	0.80	24.32**	33.06**
NUM103XNUM124	-2.65*	-2.13**	3.05	1.36	8.82*	22.31**
NUM103XNUM113	-2.14*	-1.79**	1.44	-0.56	15.84*	28.00**
NUM103XNUM123	-7.96*	-5.67	-0.28	-2.17	-17.29*	-9.09
NUM103XNUM117	-1.08*	0.36	3.14	0.00	-9.56*	1.65
NUM103XNUM105	-2.97	1.95*	28.37**	28.01*	6.61	14.15*
NUM103XNUM120	-6.53	-6.03*	3.20	0.00	-0.36	14.88*
NUM009XNUM103	-0.06	0.01	0.06	0.03	0.00	0.07
NUM009XNUM124	-4.96*	-3.94*	10.12*	9.09	-13.49*	-9.42
NUM009XNUM113	-1.61	-1.43*	3.78	-0.80	-5.88	12.00*
NUM009XNUM123	-6.43*	-3.58	11.17*	10.43*	-9.54*	-7.25*
NUM009XNUM117	-10.31	-9.49	7.71	7.14	-5.88	-1.45
NUM009X105NUM	-5.42*	-1.17	12.72*	10.16*	-18.03*	-5.66
NUM009XNUM120	0.00*	1.08	11.74*	5.61	-10.14*	-3.62
NUM124XNUM103	-0.24	-0.22**	0.14*	0.12*	0.08	0.21**
NUM124XNUM009	-0.18*	-0.14*	-0.02	-0.03	-0.14*	-0.10*
NUM124XNUM113	-12.92*	-12.14	16.38*	12.26*	-14.74	7.00
NUM124XNUM123	-11.88	-10.18	-13.59*	-13.82*	-6.08*	-4.14
NUM124XNUM117	-8.77**	-6.93**	-13.29*	-14.55*	-19.21	-19.21**
NUM124X105NUM	-6.47**	-1.17**	3.87	2.45	25.29**	51.89**
NUM124XNUM120	-10.53*	-10.53*	-8.86	-13.08*	-13.92**	-11.92*
NUM113XNUM103	-0.11*	-0.09**	0.08	0.06	0.20*	0.33**
NUM113XNUM009	-0.17**	-0.15**	0.05	0.01	0.24**	0.47**
NUM113XNUM124	-0.13	0.00*	0.00	-0.04	-0.02	0.23*
NUM113XNUM123	-21.53*	-19.29**	8.17	4.07	19.18*	46.00**
NUM113XNUM117	-13.00	-12.04**	30.74**	24.34**	5.18	32.00*
NUM113XNUM105	-13.06*	-8.98*	6.02	3.64	-21.36*	-19.00**

NUM113XNUM120	-6.55**	-5.71**	12.76*	11.44*	30.23**	68.00*
NUM123XNUM103	-0.13	-0.06	0.06	0.04	-0.07	0.02
NUM123XNUM009	-0.10*	-0.04	0.07	0.07	-0.10*	-0.07
NUM123XNUM124	-0.13	-0.01	0.04	0.04	0.01	0.03
NUM123XNUM113	25.20*	0.12	40.30*	0.09	10.90	0.09
NUM123XNUM117	-11.23**	-7.66*	4.69	3.44	-17.57	-15.86*
NUM123XNUM105	3.26*	11.33**	8.82	7.05	5.18**	24.53**
NUM123XNUM120	-8.43**	-6.67**	15.38*	9.76	-22.11*	-18.62**
NUM117XNUM103	-0.18	-0.17*	0.03	0.00	0.05*	0.18*
NUM117XNUM009	-0.16**	-0.06**	0.02	0.01	-0.22	-0.19**
NUM117XNUM124	-0.09	0.00	-0.02	-0.03	0.00**	0.00
NUM117XNUM113	-0.04	0.10**	0.08	0.02	0.00*	0.26**
NUM117XNUM123	0.00	0.13*	0.04*	-0.11*	0.06**	0.08*
NUM117XNUM105	-9.81**	-6.64	12.11*	8.99	-20.62	-3.77
NUM117XNUM120	-5.90*	-4.01*	6.89	0.53	-14.56*	-12.58*
NUM105XNUM103	-0.12**	-0.10**	0.04	0.04	-0.42**	-0.38**
NUM105XNUM009	-0.08**	-0.02**	0.12*	0.10	-0.57**	-0.50**
NUM105XNUM124	-0.06	0.01*	0.07	0.05	-0.04	0.16*
NUM105XNUM113	-0.12**	0.01**	0.00	-0.03	0.29**	0.33**
NUM105XNUM123	-0.11	-0.14*	-0.01	-0.02	-0.04	0.17*
NUM105XNUM117	-0.01	0.10*	0.01	-0.02	-0.04	0.17*
NUM105XNUM120	-0.18	5.47**	8.99	5.32	4.55	30.19**
NUM120XNUM103	-0.16*	-0.10**	0.08	0.05	0.15*	0.33**
NUM120XNUM009	-0.05	-0.05	0.11*	0.05	-0.01	0.07
NUM120XNUM124	-0.08*	0.02*	0.09	-0.01	-0.11*	-0.09*
NUM120XNUM113	-0.12	-0.05**	0.09	0.08	0.02	0.32**
NUM120XNUM123	-0.13	-0.05	0.03	-0.02	-0.07	-0.03
NUM120XNUM117	-0.02*	0.04	0.13*	0.06	-0.09*	-0.07
NUM120XNUM105	-0.04*	-0.03	0.20*	0.16*	-0.14*	0.07

* P≤ 0.05 ** P≤0.01

Oleic acid (% age): Oleic acid is one of the major desirable components of Brassica seed meal therefore for getting improved Brassica varieties/lines positive levels of heterosis and heterobeltiosis for oleic acid is considered. Data regarding oleic acid content showed that out of 56 crosses, 49 crosses had positive values where figures ranged from 0.00% to 40.30%. Significant positive heterosis was monitored for 17 crosses where the maximum positive value (40.30%) was recorded in cross NUM123xNUM113. However, data regarding heterobeltiosis showed that out of 56 crosses, positive values were recorded for 41 crosses where data ranged from 0.00% to 28.01%. Significant positive heterobeltiosis was detected for 8 crosses with the maximum positive values (28.01%) being found in cross NUM103xNUM105 (Table 2).

Linolenic acid (% age): Linolenic acid content is an undesirable component of Brassica oil, which make this oil incongruous for human utilization. Therefore negative heterosis and heterobeltiosis is desirable for linolenic acid. Data regarding linolenic acid content, demonstrated that out of 56 crosses, 32 crosses contained significantly negative heterosis where data ranged from -0.01% to -22.11%. The maximum negative value (-22.11%) was recorded in cross NUM123xNUM120. Heterobeltiosis values for linolenic acid content showed that out of 56 crosses, negative values were detected for 22 crosses. The data for these crosses ranged from -0.07% to -19.00 %. Significant negative heterobeltiosis was recorded for 11 crosses where the maximum negative values (-19.00) was witnessed in cross NUM113xNUM105 (Table 2).

DISCUSSION

Heterosis and heterobeltiosis play an important role in the in hybrid breeding program for future use. In our study majority of the desirable traits produced positive Heterosis and heterobeltiosis while undesirable ones produce negative Heterosis and heterobeltiosis.

The erucic acid content of Brassica oil and glucosinolate content in the seed meal are the major undesirable components of Brassica that makes its oil deleterious to human and animal health. Lower levels of these compounds are the major objectives of breeding brassica for quality. Hence, lower values of heterosis and heterobeltiosis were desirable in the present experiment. In our experiment some F_1s showed significantly negative values both for heterosis and heterobeltiosis for these traits indicating the importance of these crosses in the development of new genotypes. These are supported previous study of Kumar *et al*. (2013), Bijral and Sharma (1996), who reported significant heterosis for glucosinolate contents and seed yield. Similarly, Pourdad and Sachan (2003) studied heterosis and inbreeding depression in rapeseed. Another hybrid displayed highest negative heterobeltiosis for glucosinolate concentration while another one yielded highest negative heterobeltiosis for erucic acid content. Burton *et al*. (2003) found decrease in amount of glucosinolate concentrations. Guang and Tonei (1997) also bred a new low erucic acid rape (*B. napus*) with good oil quality. The linolenic acid content of Brassica oil in the seed meal is also another undesirable component that make its oil deleterious to human and animal health (Kumar, 2013). Lower levels of this compound and high level of oleic acid are the major objectives of breeding Brassica for quality. Hence, lower values of heterosis and heterobeltiosis were desirable for protein, linolenic acid and high level oleic acid in the present experiment. In the present experiment some F_1s showed significantly negative values both for heterosis and heterobeltiosis for these traits indicating the importance of these crosses in the development of new genotypes. Our result is similar to the finding of Hu *et al*. (1996) who calculated positive heterosis for seed oil content, negative heterosis for protein content and no heterosis for total glucosinolate content.

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