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ESTIMATION OF HETEROSIS FOR SOME IMPORTANT TRAITS IN MUSTARD (*BRASSICA JUNCEA L.*)

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ABSTRACT

For the estimation of mid-parent and better-parent heterosis in *Brassica juncea* L. genotypes an experiment was conducted at NWFP Agricultural University, Peshawar during 2004-05 and 2005-06 using 8 x 8 full diallel. All the 56 F_1 hybrids and their parents were planted in a randomized complete block design with two replications. Out of 56 hybrids, negative mid-parent and better-parent heterosis were estimated in 15 and 10 hybrids for days to 50% emergence, in 20 and 11 hybrids for days to 50% flowering, in 34 and 49 crosses for days to physiological maturity and in 37 and 34 crosses for plant height, respectively whereas positive heterosis were estimated in 12 and 10 crosses for number of primary branches plant^{-1}. However, significant negative mid-parent and better-parent heterosis were recorded in 5 and 4 hybrids for days to 50% emergence, in 05 and 03 for days to 50% flowering, in 10 and 8 for days to physiological maturity, in 7 and 36 for plant height while significantly positive heterosis was recorded in 27 and 4 crosses for number of primary branches plant^{-1} respectively. Better-parent heterosis reduced to 27% for emergence, 3.85% for flowering, 4.08% for maturity and 22.63% for plant height whereas it reached to 44% for branches plant^{-1}. Among parents, NUM103, NUM113, NUM123 and NUM117 proved to be superior when used as parents in most of the hybrid combinations. Hybrids NUM9xNUM113, NUM103xNUM113, NUM123xNUM117, NUM123x NUM113 and NUM123xNUM124 were best for different characters and their further utilization in breeding programs is suggested.

Keywords: heterosis, mid-parent, better-parent, mustard, *Brassica juncea* L, flowering, maturity.

INTRODUCTION

Pakistan is facing huge shortage of edible oil for a long time. Lack of high yielding varieties and lower production per unit area are the major reasons in addition to rapid rise in population and living standard of people, for this shortage. The domestic oil production hardly meets 30% of the national demand whereas the remaining 70% is met through the import by spending huge foreign exchange. A rough estimate shows that in 2004-2005 country imported 1.3 million tones of palm oil to meet the national requirement of 1.9 million tones (Anonymous, 2005) by spending 31 billions rupees. In addition, the import of edible oil is continuously increasing with an alarming rate of 13% annually (Razi, 2004). In order to save foreign exchange, government has encouraged the cultivation of different oilseed crops in the country. Since the production potential of traditional oil seed crops, such as mustard, cottonseed and rape is limited, efforts are being made to supplement the local production through the cultivation of non-traditional oil seed crops, such as canola, sunflower, safflower and soybean.

Rapeseed (*Brassica napus, Brassica campestris* and *Brassica juncea*) is grown world wide as a source of edible oil (Downey and Rakow, 1987). These annual crops can be successfully grown in different types of soils (French, 1977). Brown or Indian mustard (*Brassica juncea*) is one of the most important species in the genus *Brassica*. It has great yield potentials for semi arid conditions and known to be more droughts tolerant and shattering resistant than *Brassica napus* and *Brassica campestris*. It matures earlier than *Brassica napus* and consequently escapes the attack of aphids and hairy caterpillar. It is also more lodging resistant as compared to rapeseed (*Brassica napus* and *Brassica campestris*). Although it is widely and extensively grown as a vegetable, it is being grown more for its seeds, which yield an essential oil and condiment. The oil content of mustard varies between 28.6 to 45.7%. Its oil is one of the major edible oils in Indian subcontinent where it is mainly used for edible purposes, hair oil and lubricants. Its seed residue is used as cattle feed and in fertilizers (Reed, 1976).

There is much scope of developing new mustard varieties, containing low levels of erucic acid and glucosinolates. However one limitation of *Brassica juncea* is that the available genotypes contain higher glucosinolates and erucic acids content. Erucic acid is a fatty acid associated primarily with plants of genus *Brassica* and some other plants. Genotype, especially in *Brassica juncea* constitutes 60-65% erucic acid of the total fatty acid. Feeding experiments with animals have demonstrated that rapeseed oil, rich in erucic acid, interferes in myocardial conductance and the peripheral vascular system, decrease survival time, shorten coagulation time and increase blood cholesterol time (Renarid and McGregor, 1976) thus restricting their use as edible oil crop. On the other hand defatted Brassica oilseed meal contains about 40% protein with a well-balanced amino acid composition (Miller *et al.* 1962). Its use in human and animal nutrition is, however, limited by its glucosinolate content. Therefore there is great need to screen out breeding lines for lower levels of erucic acid and glucosinolates and higher yield potential.

The successes of hybrid breeding are the reason for its expansion in all most all major fields of agricultural

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plants and animals. Its role in vegetable and major field crops is undeniable. For developing a hybrid, as a first step information available on genetic analysis of important characters is collected. These information are then used to combine desirable traits in a single hybrid. For this purpose, genetic information on heterosis is useful for developing breeding strategies to meet the demands of increased population. It has become a common practice of the plant breeder working with crop plants to obtain genetic information from diallel cross progenies. It is necessary to have detailed information about the desirable parental combination in any breeding program which can reflect a high degree of heterotic response. Therefore, heterotic studies can provide the basis for the exploitation of valuable hybrid combinations in future breeding programs. Heterosis has extensively been explored and utilized for boosting various quality traits in brassica and other crops (Hassan *et al*. 2006). According to Pal and Sikka, (1956) heterosis is a quick, cheap and easy method for increasing crop production.

In the present studies heterosis (mid-parent and better-parent) was estimated for maturity and some important agronomic traits in F_1 generation of mustard genotypes using eight parent diallel cross experiment.

MATERIALS AND METHODS

The experiment was conducted at NWFP Agricultural University, Peshawar during 2004-2006. Eight *Brassica juncea* L. genotypes viz., NUM9, NUM103, NUM105, NUM113, NUM117, NUM120, NUM123, and NUM124 were collected from Nuclear Institute of Food and Agriculture (NIFA), Peshawar and crossed manually in all possible combinations (direct and reciprocals) in a 8 x 8 full diallel fashion during Rabi season 2004-05. All of the 56 F_1 hybrids and their parents were grown in a randomized complete block design with two replications in field conditions in 2005-06. F_1 hybrids and their parent lines were randomly assigned to experimental units/plots. Each plot comprised of two rows of 4m length with a space of 1m between rows and 30cm between plants.

The data were recorded on days to 50% emergence, days to 50% flowering, days to physiological maturity, plant height and number of primary branches plant^{-1}. The data was subjected to analyses of variance according to Steel and Torrie (1980) and the percent increase (+) or decrease (-) of F_1 cross over mid-parent as well as better-parent was calculated to observe heterotic effects for all the parameters. The estimate of heterosis over the mid-parent and better-parent was calculated using the procedure of Matzingar *et al.* (1962). The difference of F_1 mean from the respective mid-parent and better-parent value was evaluated by using t-test according to Wynne *et al.* (1970).

RESULTS

Analysis of variance revealed highly significant (at P≤0.01) differences among the parents and their F_1 hybrids for 50% flowering, days to physiological maturity, plant height and number of branches plant^{-1} whereas days to 50% emergence was found non-significant (Table-1). All the 56 hybrids were compared with mid and better parents for the estimation of mid-parent heterosis and better-parent heterosis, respectively.

Table-1. Mean squares for days to 50% emergence, 50% flowering, and physiological maturity, plant height and number of primary branches plant^{-1} in Brassica juncea genotypes.

		Characters				
S.O.V.	**D.F.**	**Emergence**	**Flowering**	**Maturity**	**Plant height**	**Branches Plant^{-1}**
Replications	1	0.15	0.13	0.84	24.05	0.63*
Genotypes	63	0.59**	1.64*	1.69**	1073.27**	7.67**
Error	63	0.81	1.46	0.42	53.15	0.93

^{ns}= Non-significant ** = Significant at 1% probability level.

Days to 50% emergence

Emergence is an important parameter indicating the potential of seed germination. Earlier emergence in Rabi grown brassica helps to develop seedlings before onset of severe winter and it also provide sufficient time for vegetative growth that could contribute towards higher yields. Therefore, early emergence is desirable and negative heterosis for days to emergence is useful. Table-2 showed that out of 56 crosses, 15 crosses had negative heterosis over mid-parent and the negative effects ranged from -7.5 to -30.31. The maximum decrease over mid-parent was recorded in crosses NUM103x NUM113 and NUM123 x NUM117. Of the crosses showing negative values only 5 crosses exhibited significant differences. Heterosis effects over better parent showed that out of 56 crosses negative values were displayed by 10 crosses. The data for negative values ranged from -12 to -27.0% where the maximum heterosis over better parent was recorded in crosses NUM123 x NUM113 and NUM105 x NUM103. Significant negative heterosis was observed in 4 crosses.

Days to 50% flowering

Early flowering in brassica can provide adequate time for grain formation process and can certainly cause early maturity and higher yields; therefore, negative heterosis is desirable for flowering. The data presented in

Table-2 for 50% flowering showed that out of 56 crosses, 20 crosses exhibited negative heterosis over mid-parent with a range of -0.01 to -4.52%. Among these crosses, 5 crosses showed significant values. The maximum significantly negative value (-4.52%) was recorded for cross 103 x 113. Data for better parent heterosis showed that out of 56 crosses, negative effects were observed in 11 crosses. The negative values ranged from -0.03 to -3.85%. Significant effects were recorded for 2 crosses over the better-parent with maximum negative value (-3.85%) being shown by crosses NUM123 x NUM117 and NUM117 x NUM124 (Table-2).

Table-2. Heterotic effects for days to 50% emergence, 50% flowering and physiological maturity, plant height and number of primary branches plant^{-1} in Brassica juncea L. genotypes.

Traits	Number of crosses with				Crosses with	
	Heterosis over		Significant heterosis over		The highest heterosis in rank order over	
	MP* (% range)	BP* (% range)	MP	BP	MP	BP
Emergence	15 (-7.5 to -30.31)	10 (-12 to -27)	05	04	NUM103 x NUM113 NUM123 x NUM 117	NUM123 x NUM113 NUM105x NUM103
Flowering	20 (-0.01 to -4.52)	11 (-0.03 to -3.85)	5	02	NUM123x NUM105 NUM123 x NUM117	NUM123 x NUM117 NUM117 x NUM124
Maturity	18 (-0.01 to -3.09)	14 (-0.01 to -4.07)	10	8	NUM009x NUM113	NUM123x NUM124
Plant height	17 (-0.04 to-24.62)	24 (-0.04 to -22.63	14	20	NUM123x NUM103	NUM113 x NUM 123
Branches plant^{-1}	12 (6.24 to 48.00)	10 (8.00 to 44.00)	7	4	NUM123 x NUM 117 NUM103 x NUM 113	NUM123 x NUM117 NUM103 x NUM113

* MP = mid-parent BP = better-parent

Days to physiological maturity

Early maturity is useful in most of the plant species especially brassica where delayed maturity causes losses to yield and quality of oil due to rise in temperature; therefore, negative heterosis is desirable for early maturity. Heterotic data presented in Table-2 showed that out of 56 crosses, 18 crosses showed negative heterosis over mid-parent and the data for these crosses ranged from -0.01 to -3.09%. Of these crosses, 10 crosses exhibited significant negative heterosis over mid-parent where maximum negative effects were recorded in crosses NUM009 x NUM113. Negative heterosis over better-parent was demonstrated by 14 crosses where effects ranged from -0.01 to -4.07%. Significant negative effects were recorded in 8 crosses with the maximum negative value (-4.07%) being observed for cross NUM123 x NUM124.

Plant height

Small and medium plant stature in brassica is preferred because it can tolerate heavy winds and can be prevented from lodging; therefore, negative heterosis is useful regarding plant height. Table-2 showed that out of 56 crosses, 37 crosses presented significant negative heterosis over mid parent for plant height. The data ranged from -0.01% to -38.86% where the maximum negative heterosis (-38.86%) was presented by cross 123 x 103. Data for heterosis over best parent showed that out of 56 crosses, 34 crossed exhibited negative effects where values ranged from -0.02% to -40.19%. Of these 34 crosses, significant negative value were recorded in 31 crosses where the maximum negative value (-40.19%) was recorded in cross 113 x 123.

Number of primary branches plant^{-1}

In brassica, short stature with vigorous structure containing more number of primary branches provide opportunity for more yields, so positive heterosis is desirable for number of primary branches. Heterosis estimates over mid-parent (Table-2) showed that out of 56 crosses, 12 crosses had positive effects where values ranged from 6.24% to 48.00%. Of these crosses, significant heterosis over mid parent was noted for 7 crosses with the maximum values (48%) being observed for crosses 123 x 117 and 103 x 113. Regarding best parent heterosis, it could be seen from Table-2 that out of 56 crosses, positive effects were exhibited by 10 crosses where data ranged from 8 to 44%. Of the positive values, significant heterosis over best parent were presented by 4 crosses where the maximum value was recorded for crosses 123 x117 and 103 x 113

DISCUSSION

Early emergence, flowering and maturity in brassica genotypes is preferred over late flowering/ maturing genotypes because earliness of these traits might certainly help to get early maturing lines that could not only tolerate or escape heat stress but could also provide sufficient time for the cultivation of next crop. In addition it would help to reduces losses occurred due to shattering that would ultimately enhance yields. Similarly, shorter plants with grater numbers of branches are considered desirable because these traits help plants to tolerant winds. Keeping in view the importance of early emergence, flowering and maturity and shorter plant height, emphasis was focused on negative heterosis for these characteristics. In the present experiment, negative heterotic values for these traits were noted for majority of the crosses. Crosses showing significant negative values suggested that these crosses could be used to develop new early maturing lines. Earlier findings of Nassimi *et al.* (2006) verified the results of this study. They reported significant negative mid-parent and better-parent heterosis for emergence, flowering, maturity and plant height in *Brassica napus* genotypes. The present findings are similar to earlier reports of Pourdad and Sachan (2003) who reported significant negative heterosis for days to 50% flowering and maturity and high negative heterosis for plant height. These results are further strengthened by earlier findings of Engqvist and Becker (1991) who found hybrids with earlier flowering and higher yields with slightly later in maturity. However, Hu *et al.* (1996) reported significant positive heterotic effects for plant height and seed yield plant^{-1}. The differences in the results could be due to the differences in genotypes and weather conditions.

Since number of branches plant^{-1} is one of the major yields contributing traits hence more branches plant^{-1} are desirable, therefore positive values are preferred. The presence of significantly positive heterosis for branches plant^{-1} in crosses indicates the potential of their use for developing high yielding genotypes. The presence of high levels of mid and high-parent heterosis indicates a considerable potential to embark on breeding of hybrid cultivars in *Brassica juncea*. The results of this study are similar to earlier findings of Nassimi *et al.* (2006) who reported significant positive heterosis for number of branches plant^{-1} in *Brassica napus* genotypes. Satwinder *et al.* (2000) also reported that F_1 generations expressed significant heterosis for emergence, number of primary branches, number and length of primary roots and pods, seeds pod^{-1}, yield plant^{-1} and oil content. Similarly, Jorgensen *et al.* (1995) found high positive heterosis for primary and secondary branches and other yield contributing traits. In addition, Krzymanski *et al.* (1997) found significant heterosis for seed yield, oil content and some flowering traits. Fray *et al.* (1997) also reported significant estimates of heterosis for primary branches, seed yield and siliquae plant^{-1}. However, Liu (1996) reported heterosis for more branches with greater plant height, and longer flowering period.

From the present experiment crosses NUM123 x NUM117 and NUM117 x NUM124 were found best for flowering and maturity. These can be used to develop early maturing lines.

REFERENCES

Adefris, T and C. B Heiko. 2005. Heterosis and combining ability in a diallel cross of Ethiopian mustard inbred lines. Crop Breeding. 10: 21-35.

Anonymous. 2005. Edible oil situation in Pakistan. Business News. The Daily NEWS, Islamabad, Pakistan. November 17. p. 10.

Doweny, R.K.Rakow. 1987. Rapeseed and mustard. In: Principles of cultivar development. W.R. Fehar (Ed). Macmillan Publishing Co., New York. 2: 437-486.

Engquist, G.M. and H.C. Becker. 1991. Heterosis and epistasis in rapeseed estimated from generation means. Euphytica. Vol. 58(1): 31-35.

French, R.T. 1977. Oriental and brown mustard seed production. Techniques Bulletin. 2:1-2.

Fray, M.J., P. Puangsomlee, J. Goodrich, G. Coupland, E.J. Evans, A.E. Arthur and D.J. Lydiate. 1997. The genetics of stamenoid petal production in oilseed rape (Brassica napus L.) and equivalent variation in Arabidopsis thaliana. Indian J. of Genetics and Plant Breeding. Vol. 57(2): 163-167.

Hassan, G., F. Mohammad, I.H. Khalil and Raziuddin. 2006. Heterosis and heterobeltiosis studies for morphological traits in bread wheat. Sarhad J. Agri. Vol. 22(1): 51-54.

Hu, B., F. Chen, C. Li, Q. Li, B.C. Hu, F.X. Chen, C. Li and Q.S. Li. 1996. Comparison of heterosis between cytoplasmic male sterile three-way cross and single crosses hybrids in rape (Brassica napus L.). Rosliny Oleiste. Vol. 17(1): 61-71.

Jorgensen, R.B., B. Andersen, L. Landbo, T.R. Mikkelsen, J.S. Dias, I. Crute and A.A. Monteiro. 1995. Spontaneous hybridization between oilseed rape (Brassica napus) and weedy relatives. J. of Oilseeds Research. Vol. 12(2): 180-183.

Krzymanski, J., T. Pietka, K. Krotka, R.P. Bodnaryk, R.J. Lamb and K.A. Pivnick. 1997. Resistance of hybrid canola (Brassica napus L.) to flea beetle (Phyllotreta spp.) damage during early growth. Postepy Nauk Rolniczych. Vol. 45(5): 41-52.

Liu, Z.S. 1996. Genetic and breeding studies on distant hybridization in rapeseed. II. Cross compatibility between Brassica napus and B. juncea and their F1s. Oil Crops of China. Vol. 16(3): 1-5.

Matzingar, D.F., T.J. Mann and C.C. Cockerham. 1962. Diallel crosses in Nicotiana tabaccum. Crop Sci. 2: 383-386.

Pal, B.P. and S.M. Sikka. 1956. Exploitation of hybrid vigour in the improvement of crop plants, fruits and vegetables. Indian J. of Genetics and Plant Breeding. Vol. 16(2): 95-193.

Patel, K.M and G.S Sharma. 1999. Heterosis and genetic architecture for oil content in Indian mustard. Gujarat Agricultural University Research J. Vol. 24 (2): 97-99.

Pourdad, S. S. and J. N. Sachan. 2003. Study on heterosis and inbreeding depression in agronomic and oil quality characters of rapeseed (Brassica napus L.). Seed and Plant. Vol. 19(3): 29-33.

Razi, R. 2004. Edible oil worth Rs. 31 billion imported. Business News. The Daily NEWS, Islamabad, Pakistan. July 26. p. 8.

Satwinder, K., S. Paramjit, V.P. Gupta, S. Kaur and P. Singh. 2000. Combining ability analysis for oil yield and its components in Brassica napus L. Cruciferae Newsletter. 22: 67-68.

Sheikh, I.A and J.N Singh. 2001. Heterosis in Indian mustard hybrids derived using male sterile lines for yield and component characters. Crop Research Hisar. Vol. 21(2): 98-203.

Sood, O.P, V.K Sood and H.L Thakur. 2000. Combining ability and heterosis for seed yield traits involving natural and synthetic Indian mustard (Brassica juncea L. Czern. & Coss.). Indian J. of Plant Breeding and Genetics. Vol. 60(4): 561-563

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedure of statistics. McGraw-Hill Book Co., Inc., New York, USA.

Thakur, H.L and S. Bhateria. 1993. Heterosis and inbreeding depression in Indian mustard. Indian J. of Genetics and Plant Breeding. Vol. 1(9): 60-65.

Varma, O.P, H.P Singh and P.V Singh. 1998. Heterosis and inbreeding depression in Indian mustard. Cruciferae-Newsletter. 20(2): 75-76.

Wyne, J.C., D.A. Emery and P.M. Rice. 1970. Combining ability analysis over environments in spring wheat. Wheat Infor. Serv. Japan. 67:21-24.