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Study on Heterosis in Agronomic Characters of Rapeseed (*Brassica napus* L.) Using Diallel

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Abstract: To estimate mid-parent and better-parent heterosis in *Brassica napus* L. an experiment was conducted at NWFP Agricultural University, Peshawar, during 2004-05 and 2005-06 using 8×8 full diallel crosses. All the 56 F_1 hybrids and their parents were planted in a randomized complete block design with three replications. Out of 56 hybrids, negative mid-parent and better-parent heterosis were estimated in 28 and 25 hybrids for 50% emergence, in 30 and 17 hybrids for 50% flowering, in 34 and 49 hybrids for physiological maturity and in 27 and 38 hybrids for plant height, respectively whereas positive heterosis were estimated in 28 and 23 crosses for primary/branches plant. However, significant negative mid-parent and better-parent heterosis were recorded in 6 and 7 hybrids for 50% emergence, in 17 and 04 for 50% flowering, in 11 and 20 for physiological maturity, in 27 and 36 for plant height while significantly positive heterosis was recorded in 27 and 23 crosses for primary branches/plant, respectively. Better-parent heterosis reduced to 25% for emergence, 2.78% for flowering, 4.08% for maturity and 21.22% for plant height whereas it reached to 50% for branches/plant. Among parents, NUR1, NUR2, NUR4, NUR5 and NUR9 were found superior when used in different cross combinations. Hybrids NUR3×NUR4, NUR5×NUR1 and NUR5×NUR7 could be used to develop early maturing while NUR3×NUR2 and NUR5×NUR8 would be helpful to develop medium sized with robust structured brassica lines that could be tolerant to lodging with greater yields.

Key words: Heterosis, mid-parent, better-parent, flowering, maturity

INTRODUCTION

Pakistan is facing huge shortage of edible oil for a long time. In addition to rapid rise in population and living standard of people, lack of high yielding varieties and lower production per unit area are the major reasons for the shortage of edible oil in the country. The domestic oil production hardly meets 30% of the national demand whereas 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.

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

Heterosis and heterobeltiosis have extensively been explored and utilized for boosting various quality traits in different crops. It is reported that heterosis is a quick, cheap and easy method in increasing crop production (Pal and Sikka, 1956). With sufficient level of heterosis, commercial production of hybrid varieties would be justified.

Keeping in view the importance of edible oil and its alarming situation in the country the present study was

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aimed to evaluate eight *Brassica napus* L. genotypes for heterotic effects and identify their potential hybrids for developing new genotypes.

MATERIALS AND METHODS

The study was conducted at NWFP Agricultural University, Peshawar during 2004-2006. Eight *Brassica napus* L. genotypes viz., NUR1, NUR2, NUR3, NUR4, NUR5, NUR7, NUR8 and NUR9 were collected from NIFA-Peshawar and crossed manually (hand emasculation and pollination) in all possible combinations (direct and reciprocals) in a 8×8 diallel fashion during Rabi season 2004-05.

In 2005-06, the parents and their 56 F_1 hybrids were grown in a randomized complete block design with three replications in field conditions. All the F_1 hybrids and their parent lines were randomly assigned to experimental units/plots. Each plot comprised two rows of 4 m length with space of 1 m between rows whereas seeds were planted 30 cm apart.

The data were collected on days to 50% emergence, days to 50% flowering, days to physiological maturity, plant height and number of primary branches/plant. The data were 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 Wyne *et al.* (1970).

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant (at $p \leq 0.01$) differences among the parents and their F_1 hybrids for 50% flowering, days to physiological maturity, plant height and number of branches/plant 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.

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, 28 crosses had negative heterosis over mid parent and the negative effects ranged from -6.67 to-25.00% where the maximum decrease over the mid-parent was recorded in crosses NUR5×NUR1 and NUR9× NUR7. Among negative values only 6 crosses exhibited significant differences. Heterosis effects over better parent showed that out of 56 crosses negative values were displayed by 25 crosses. The data for negative values ranged from -12.50 to -25.00% where the maximum heterosis over better parent was recorded in crosses NUR2×NUR7, NUR2×NUR8, NUR2×NUR9, NUR4×NUR1, NUR5×NUR1, NUR5×NUR4 and NUR8×NUR4. Significant negative heterosis was observed in 7 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. Data presented in Table 2 for 50% flowering showed that out of 56 crosses, 30 crosses exhibited negative heterosis over mid parent with the range of -0.46 to -2.78%. Among these crosses, 17 crosses showed significant values. The maximum significantly negative value (-2.78%) was recorded for cross NUR5×NUR7. Data for better parent heterosis showed that out of 56 crosses, negative effects were observed in 17 crosses. The negative values ranged from -0.92 to -2.78%. Significant effects were recorded for 4 crosses over the better parent with the maximum negative (-2.78%) value being shown by cross NUR5×NUR7 (Table 2).

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 I: Mean squares for days to 50% emergence, 50% flowering and physiological maturity, plant height and number of primary branches/plant in *Brassica napus* L. genotypes

	Characters					
SOV	DF	Emergence	Flowering	Maturity	Plant height	Branches/plant
Replications	2	0.19	4.25	0.81	23.81	4.25
Genotypes	63	0.55^{ns}	27.05**	1.42**	515.25**	9.29**
Error	126	0.82	0.45	0.39	52.85	0.72

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

Table 2: Heterotic effects for days to 50% emergence, 50% flowering and physiological maturity, plant height and number of primary branches/plant in *Brassica napus* L. genotypes

Traits	No. of crosses with heterosis over MP* (% range)	No. of crosses with heterosis over BP* (% range)	No. of crosses with significant heterosis over MP	No. of crosses with significant heterosis over BP	Crosses with the highest heterosis in rank order over MP	Crosses with the highest heterosis in rank order over BP
Emergence	28 (-6.67 to -25.00)	25 (-12.50 to -25.00)	06	07	NUR5×NUR1	NUR9×NUR7
					NUR2×NUR7	NUR2×NUR8
						NUR2×NUR9
						NUR4×NUR1
						NUR5×NUR1
						NUR5×NUR4
						NUR8×NUR4
Flowering	30 (-0.46 to -2.78)	17 (-0.92 to -2.78)	17	04	NUR5×NUR7	NUR5×NUR1
Maturity	34 (-0.01 to -3.06)	49 (-0.01 to -4.08)	11	20	NUR3×NUR4	NUR5×NUR1
						NUR5×NUR1
Plant height	27 (-0.01 to -22.59)	38 (-0.01 to -21.22)	27	36	NUR3×NUR2	NUR3×NUR2
Branches/ plant	28 (5.26 to 60.00)	23 (10.00 to 50.00)	27	23	NUR5×NUR8	NUR9×NUR8
					NUR5×NUR8	NUR9×NUR8

*MP = Mid Parent BP = Better Parent

Table 2 showed that out of 56 crosses, 34 crosses showed negative heterosis over mid parent and the data for these crosses ranged from -0.01 to -3.06%. Of these crosses, 11 crosses exhibited significant negative heterosis over mid parent where maximum negative effects were recorded in crosses NUR3×NUR4 and NUR5×NUR7. Negative heterosis over better parent were demonstrated by 49 crosses where effects ranged from -0.01 to -4.08%. Significant negative effects were recorded in 20 crosses with the maximum negative value (-4.08%) being observed for cross NUR5×NUR7.

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, 27 crosses presented significant negative heterosis over mid parent for plant height. The data ranged from -0.01 to -22.59% where the maximum negative heterosis (-22.59%) was presented by cross NUR3×NUR2. Data for heterosis over best parent showed that out of 56 crosses, 38 crossed exhibited negative effects where values ranged from -0.01 to -21.22%. Of these 38 crosses, significant negative values were recorded in 36 crosses where the maximum negative value (-21.22%) was recorded in cross NUR3×NUR2.

Number of primary branches/plant: 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, 28 crosses had positive effects where values ranged from 5.26 to 60.00%. Of these crosses, significant heterosis over mid parent was noted for 27 crosses with the maximum values (60%) being observed for crosses NUR5×NUR8 and NUR9×NUR8. Regarding best parent heterosis,, it could be seen from Table 2, that out of 56 crosses, positive effects were exhibited by 23 crosses where data ranged from 10.00 to 50.00%. Of the positive values, significant heterosis over best parent were presented by 23 crosses where the maximum value was recorded for crosses NUR5×NUR8 and NUR9×NUR8.

DISCUSSION

Early emergence provides early start of vegetative phase which helps plantlets to strengthen against forthcoming winter. Similarly early flowering helps plants to attain more time for grain filling whereas early maturity can help plants to escape or mature earlier than hot weather of summer. 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 enhanced yields. However, shorter plants with robust structure possessing increased numbers of branches are considered more tolerant to winds hence are more productive. 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. Since number of branches/plant is one of the major yield contributing traits hence more branches/plant are desirable therefore positive values were preferred. The presence of significantly positive heterosis for branches/plant in our crosses indicate 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 napus*. Our 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 heterobeltiosis for plant height. Our results are further strengthened by the earlier findings of Engquist and Becker (1991) who found hybrids with earlier flowering and higher yields with slightly later in maturity. Our results are similar to the earlier findings of Satwinder *et al.* (2000), who reported that F_1 generations expressed significant heterosis for emergence, number of primary branches, number and length of primary roots and pods, seeds/pod, yield/plant 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. However, Liu (1996) reported heterosis for more branches with greater plant height and longer flowering period. Similarly, Hu *et al.* (1996) reported significant positive effects of heterosis for plant height and seed yield/plant. The differences in the results could be due to the differences in genotypes and weather conditions.

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