http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 9 (11): 2132-2136, 2006
ISSN 1028-8880

Heterotic Studies for Yield Associated Traits in *Brassica napus* L. Using 8×8 Diallel Crosses

Abdul Wahab Nassimi, Raziuddin and Naushad Ali
Department of Plant Breeding and Genetics, NWFP Agricultural University, Peshawar, Pakistan

Abstract: To estimate heterosis over mid-parent and better-parent of F_1 hybrids in *Brassica napus* L. an experiment was conducted 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, positive mid-parent and better-parent heterosis were found in 44 and 32 hybrids for number of pods/raceme, in 27 and 19 hybrids for number of pods/plant, in 27 and 15 hybrids for pod length, in 26 and 20 hybrids for number of seeds/pod, in 50 and 39 crosses for 1000-seed weight and in 21 and 07 crosses for yield/plant. However, significant positive mid-parent and better-parent heterotic effects were recorded in 44 and 32 hybrids for pods/raceme, in 26 and 19 hybrids for pods/plant, in 11 and 09 hybrids for pod length, in 21 and 20 hybrids for seeds/pod and in 07 and 04 crosses for 1000-seed weight. Better-parent heterosis reached to 66.67% for pods/raceme, 60.85% for pods/plant, 16.03% for pod length, 27.27% for seeds/pod, 54.62% for 1000-seed weight and 1.02% for grain yield. Among parents, NUR1, NUR4, NUR5, NUR7, NUR8 and NUR9 proved to be superior when used as parents in most of the hybrid combinations. Crosses NUR1×NUR7, NUR1× NUR9, NUR5× NUR4, NUR4×NUR9, NUR3×NUR9 and NUR8×NUR9 were best for yield associated traits and their further utilization in breeding programmes would be useful for developing high yielding genotypes.

Key words: Heterosis, mid-parent, better-parent, *Brassica napus* L. diallel, yield

INTRODUCTION

The shortage of edible oils in the country offers great challenges to the plant breeders. The domestically produced edible oil hardly meets 30% of the national demand whereas remaining 70% is met through the import by spending huge foreign exchange (Anonymous, 2005). Furthermore the gap between local production and consumption is continuously widening at the rate of 13% annually (Razi, 2004). This alarming situation is pushing plant scientists to explore new ways and means not only to enhance per unit yield upto the maximum potential of the existing edible oil crops but also to introduce new high yielding crops like canola.

The success of hybrid breeding is the reason for its expansion in all most all major fields of agricultural plants and animals. Heterosis is defined as the superiority of a hybrid over its parents (Pourdad and Sachan, 2003) and is considered as a quick, cheap and easy method in increasing crop production (Pal and Sikka, 1956). Different researchers reported substantial heterosis in major oilseed Brassica (Teklewold and Becker, 1991; Leon and Becker, 1995; McVetty, 1995) that stimulated a worldwide interest for developing hybrid cultivars. In Canada, China and Europe, hybrids are becoming the major cultivar types in *B. napus* cultivation (Dianrong, 1999; Frauen *et al*., 2003). Identifying parental combination with strong yield heterosis is the most important step in developing hybrids (Diers *et al*., 1996; Becker *et al*., 1999; Melchinger, 1999). The level of genetic diversity between parents has been proposed as a predictor of F_1 performance and heterosis (Moll *et al*., 1965; Falconer and Mackay, 1996). As one of the most important sources of edible oil, *Brassica napus* is grown worldwide. At present, hybrid cultivars have higher productivity than conventional ones and their seed quality (contents of erucic acid and glucosinolates) has also been greatly improved (Fu, 2000). Therefore, the development of commercial F_1 hybrids of Brassica species has attracted considerable interest in breeders. F_1 hybrids produced from crosses between different varieties had high heterosis for yield traits in rapeseed (Brandle and McVetty, 1990; Banks and Beversdorf, 1994; Ali *et al*., 1995; Esch and Wricke, 1995; Starmer *et al*., 1998).

Keeping in view the importance of edible oil and its alarming situation in the country the present study was aimed to evaluate eight *Brassica napus* L. genotypes for heterotic effects and identify their potential hybrids for developing new genotypes.

Corresponding Author: Dr. Raziuddin, Department of Plant Breeding and Genetics, NWFP Agricultural University, Peshawar-Pakistan Tel: 091-9216839

MATERIALS AND METHODS

The experiment 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 (NUR for National Uniform Rapeseed Yield Trail) were crossed manually (hand emasculation and pollination) in all possible combinations (direct and reciprocals) in a 8×8 diallel fashion during the 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 yield associated traits like number of pods main/raceme, number of pods/plant, pod length, number of seeds/pod, 1000 seed weight and seed yield/plant. The analyses of variance was computed 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 Matzinger *et al.* (1962). The difference of F_1 mean from the respective mid parent and better parent value was evaluated by using a t-test according to Wyne *et al.* (1970).

RESULTS

Mean square values presented in Table 1 showed that highly significant differences ($p \leq 0.01$) were observed among mean values of all the yield associated traits studied in this experiment viz., number of pods main/raceme, number of pods/plant, pod length, number of seeds/pod, 1000 seed weight, seed yield/plant in *Brassica napus* L. genotypes.

Number of pods main/raceme: Since number of pods main raceme^{-1} is considered major yield associated trait and more number of pods can contribute in higher grain yield therefore, positive heterosis is desirable for this trait. Effects of heterosis over mid parent (Table 2) showed that out of 56 crosses, 45 crosses showed positive heterosis for number of pods/main raceme^{-1} where data ranged from 0.06 to 78.57%. Among these crosses, 44 crosses showed significant positive effects, where the maximum effects were recorded for cross NUR8×NUR9. Positive heterosis over better parent was recorded for 33 crosses where effects ranged from 0.01 to 66.67%. Significant positive heterosis over better parent was recorded in 32 crosses with maximum effects being observed in NUR8×NUR9.

Number of pods/plant: Number of pods/plant is the most important factor of grain yield in brassica crop therefore more pods/plant would certainly results in greater yield per unit area, hence, positive heterosis is desirable for number of pods/plant. Heterosis effects over mid parent concerning to number of pods plant^{-1} indicated that out of 56 crosses, 27 crosses exhibited positive heterosis and the values ranged from 0.10 to 78.30%. Among these crosses, 26 crosses, presented significant positive heterosis over mid parent, where the maximum positive value was recorded in cross NUR1×NUR7. Heterosis effects over better parent for number of pods/plant, demonstrated that out of 56 crosses, positive effects were noted in 19 crosses where values ranged from 0.09 to 60.85%. Significant positive heterosis over better parent was exhibited by 19 crosses with maximum positive values being observed in cross NUR1×NUR7 (Table 2).

Pod length: Longer pod would contain more and bulky seeds which would directly contribute in higher yields; therefore, positive heterosis is useful for pod length. Heterosis effects showed that 27 crosses presented positive effects over mid parent for pod length and the values ranged from 0.02 to 33.96%. Of these crosses, 11 crosses showed significant positive effects where the maximum estimate was observed in cross NUR7×NUR9. Positive heterosis over better parent was noted in 15 crosses and values ranged from 0.03 to 16.03%. Significant positive effects were identified for 9 crosses where the maximum positive value was noted for NUR5×NUR4 (Table 2).

Table 1: Mean squares for number of pods main/raceme, number of pods/plant, pod length, number of seeds/pod, 1000 seed weight, seed yield/plant in *Brassica napus* L. genotypes

		Characters					
SOV	df	Pods/raceme	Pods/plant	Pod length	Seeds/pod	1000 seed weight	Seed yield/plant
Replications	2	7.65	327.55	0.31	30.29	0.02	0.55
Genotypes	63	575.11**	8825.47**	3.25**	23.34**	1.34**	180.32**
Error	126	12.74	29.41	0.03	2.11	0.02	0.56

** = Significant at $p \leq 0.01$% probability level

Table 2: Heterotic effects for number of pods main/raceme, number of pods/plant, pod length, number of seeds/pod, 1000 seed weight, seed yield/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
No. Pods/raceme	44(0.06 to 78.57)	33(0.01 to 66.67)	44	32	NUR8×NUR9	NUR8×NUR9
No. Pods/plant	27(0.10 to 78.30)	19(0.09 to 60.85)	26	19	NUR1×NUR7	NUR1×NUR7
Pod length	27(0.02 to 33.96)	15(0.03 to 16.03)	11	09	NUR7×NUR9	NUR5×NUR4
No. Seeds/pod	26(0.02 to 31.82)	20(0.04 to 27.27)	21	20	NUR5×NUR4	NUR3×NUR9
1000 seed weight	50(0.01 to 66.18)	39(0.16 to 54.62)	07	04	NUR7×NUR9	NUR1×NUR9
Seed yield/plant	21(0.00 to 1.53)	07(0.00 to 1.02)	00	00	NUR3×NUR9 NUR4×NUR9 NUR8×NUR9	NUR8×NUR9

*MP = Mid Parent, BP = Better Parent

Number of seed/pod: Since number of seed/pod directly contributes towards grain yield therefore, positive heterosis is desirable. Data showed that out of 56 crosses, 26 crosses displayed positive heterosis over mid parent and the effects ranged from 0.02 to 31.82%. Of these crosses, significant positive heterosis over mid parent was recorded for 21 crosses where the maximum value was observed in cross NUR5×NUR4. Of total 56 crosses, positive heterosis over better parent was noted in 20 crosses, where data ranged from 0.04 to 27.27%. Significant positive effects were recorded for 20 crosses where the maximum positive value was recorded for cross NUR3×NUR9 (Table 2).

1000 seed weight: Greater seed weights certainly contribute towards higher production therefore; positive heterosis is desirable for 1000 seed weight. Heterosis over mid parent for 1000 seed weight (Table 2) showed that out of 56 crosses, 50 crosses exhibited positive heterosis. The data for crosses showing positive heterosis over mid parent ranged from 0.01 to 66.18%. Of these crosses, significant heterosis was noted in only 07 crosses where the maximum positive value (66.18%) was recorded in cross NUR7×NUR9. Data regarding heterosis over better parent for 1000 seed weight showed that out of 56 crosses, positive values were recorded in 39 crosses where data ranged from 0.16 to 54.62%. Significant positive effects were noticed for 4 crosses with the maximum value being observed in cross NUR1×NUR9.

Seed yield/plant: Like other crops seed yield/plant is considered to be the main contributor towards grain yields per unit area in brassica; therefore, positive heterosis is considered useful for selecting hybrids for seed yield/plant. Effects of heterosis over mid parent for grain yield/plant showed that out of 56 crosses, only 07 crosses presented positive but negative heterosis and the values ranged from 0.00 to 1.53%. However the maximum heterosis over mid parent was recorded for crosses NUR3×NUR9, NUR4×NUR9 and NUR8xNUR9. Regarding heterosis over better parent, positive but non significant effects were observed for 07 crosses where data ranged from 0.00 to 1.02 and the maximum effect was recorded in cross NUR8×NUR9.

DISCUSSION

Number of pods/plant, pod length, number of seeds/pod, 1000 seed eight are major yield associated component and are directly linked with yield in brassica. Therefore significant positive heterosis over both mid parent and better-parent is desirable for these traits for the enhancement of yield in a line. Significant positive values for heterosis were recorded in different F_1 hybrids for the above mentioned traits. The F_1 hybrids that surpassed their respective parents could be an asset for breeders to develop high yielding genotypes. Present results are similar to the earlier findings of Satwinder *et al.* (2000), who reported that F_1 generations expressed significant heterosis for number of primary branches, number and length of pods, seeds/pod, yield/plant and oil content. Similarly Krzymanski *et al.* (1997) found significant heterosis for seed yield, oil content and some flowering traits. Their report showed that the mean heterosis for seed yield over the mid-parental mean was 24.71%. Present results are also confirmed by the findings of Srivastava and Rai (1997) who reported highest value of better-parent heterosis for seed yield. Similarly the superiority of F_1 hybrids for seed yield/plant was also reported by Davik (1997). Hu *et al.* (1996) reported significant positive effects of heterosis for plant height and seed yield/plant. Jorgensen *et al.* (1995) also found high positive heterosis for primary and secondary branches, pods on main shoot, seeds/pod, seed yield and oil content. Present results are also confirmed by Fray *et al.* (1997), who reported significant heterotic estimates for seed yield, primary branches and siliquae/plant. Shen *et al.* (2005) reported that pods/plant had the highest heterosis, while 1000 seed weight had the lowest heterosis. Similarly other reports indicated that F_1

hybrids produced from crosses between different varieties had high heterosis for yield traits and no significant heterosis for seed oil content in rapeseed (Starmer *et al*., 1998). Among the yield traits, siliques/plant had the greatest heterosis, followed by seeds/silique and 1000 seed weight (Fu, 2000). Jorgensen and Andersen (1997) reported strong positive heterosis for dry matter yield with high yielding F_1s. However, Cheung *et al.* (1997) reported that better parent heterosis was rather low and the majority of hybrids were generally inferior compared to their better parent. The reason for the difference could be difference genotype and the environmental conditions.

ACKNOWLEDGMENTS

The first author was a recipient of M.Sc. (Honors) fellowship from USAID AUP-Peshawar. This project was sponsored by HEC-AUP project for 2004-2006.

REFERENCES

Ali, M., L.O. Copeland, S.G. Elias and J.D. Kelly, 1995. Relationship between genetic distance and heterosis for yield and phenotypic traits in winter canola (*Brassica napus* L.). Theor. Applied Genet., 91: 118-121.

Anonymous, 2005. Edible oil situation in Pakistan. Business news. Daily The NEWS Islamabad-Pakistan. November 17, 2005, pp: 10.

Banks, P.R. and W.D. Beversdorf, 1994. Self-incompatibility as a pollination control mechanism for spring oilseed rape, *Brassica napus* L. Euphytica, 75: 27-30.

Becker, H.C., H. Löptien and G. Röbbelen, 1999. Breeding: An Overview. In: Biology of *Brassica* Coeno species. Gomez-Campo, C. (Ed.), Elsevier Amsterdam, pp: 413-460.

Brandle, J.E. and P.B.E. McVetty, 1990. Geographical diversity, parental selection and heterosis in oilseed rape. Can. J. Plant Sci., 70: 935-940.

Cheung, W.Y., G. Champagne, N. Hubert, L. Tulsieram, D. Charne, J. Patel and B.S. Landry, 1997. Conservation of S-locus for self-incompatibility in *Brassica napus* L. and *Brassica oleracea* L. Euphytica, 98: 1-2.

Davik, J., 1997. Parameter estimates from generation means in Swedes (*Brassica napus* ssp. rapifera L.). Biuletyn Instytutu Hodowli I Aklimatyzacji Roslin. 201: 361-371.

Dianrong, L., 1999. Hybrid Seed Production in Rapeseed. Heterosis and Hybrid Seed Production in Agronomic Crops. In: Food product press. Basra, A.S. (Ed.), New York, pp: 217-260.

Diers, B.W., P.B.E. McVetty and T.C. Osborn, 1996. Relationship between heterosis and genetic distance based on restriction fragment length polymorphism markers in oilseed rape (*Brassica napus* L.). Crop Sci., 36: 79-83.

Esch, E. and G. Wricke, 1995. Investigations on self-incompatibility in *Brassica napus* L. towards hybrid breeding. Proc. 9th Intl. Rapeseed Cong., July 4-7, 1995, Cambridge, UK., pp: 83-85.

Falconer, D.S. and T.F.C. Mackay, 1996. Introduction to quantitative genetics, 4th Edn. Longman, England.

Frauen, M., J. Noaack, W. Paulmann and F. Grosse, 2003. Development and perspective of MSL-hybrids in winter oilseed rape in Europe. In: Proceedings of 11th Int. Rapeseed Cong, July 6-10 2003, Copenhagen, Denmark, pp: 316-318

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*. Ind. J. Genetics Plant Breed, 57: 163-167.

Fu, T.D., 2000. Breeding and Utilization of Rapeseed Hybrid. 2nd Edn. Hubei Science and Technology Press, Wuhan-China.

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, 17: 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. Oilseeds Res., 12: 180-183.

Jorgensen, R.B. and B. Andersen, 1997. Spontaneous hybridization between oilseed rape (*Brassica napus*) and weedy *B. campestris* (Brassicaceae): A risk of growing genetically modified oilseed rape. J. Genet. Breed., 48: 253-257.

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* sp.) damage during early growth. Postepy Nauk Rolniczych. 45: 41-52.

Leon, J. and H.C. Becker, 1995. Rapeseed (*Brassica napus* L.) Genetics. In: Physiological Potential for Yield Improvement of Annual Oil and Protein Crops. Diepenbrock, W. and H.C. Becker (Eds.). Adv Plant Breed. Supplement to the J. Plant Breed. Blackwell Wiss. Verlag, Berlin, Wien, 17: 53-90.

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

McVetty, P.B.E., 1995. Review of performance and seed production of hybrid Brassicas. In: Proceedings of 9th International Rapeseed Conference, Cambridge, July 4-7 1995, pp: 98-103.

Melchinger, A.E., 1999. Genetic Diversity and Heterosis. In: Genetics and Exploitation of Heterosis in Crops. Coors, C.G. and S. Pandey (Eds.), American Society of Agronomy, Madison, pp: 99-118.

Moll, R.H., J.H. Lonnquist, J. Velez Fortuno and E.C. Johnson, 1965. The relationship of heterosis and genetics divergence in maize. Genetics, 52: 139-144.

Pal, B.P. and S.M. Sikka, 1956. Exploitation of hybrid vigor in the improvement of crop plants, fruits and vegetables. Indian J. Genet. Plant Breed., 16: 95-193.

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, 19: 29-33.

Razi, R., 2004. Edible oil worth Rs-31 billion imported. Business News. Daily The NEWS, Islamabad-Pakistan. July 26, 2005, pp: 08.

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 Newslett., 22: 67-68.

Shen, J.X., T.D. Fu, G.S. Yang, C.Z. Ma and J.X. Tu, 2005. Genetic analysis of rapeseed self-incompatibility lines reveals significant heterosis of different patterns for yield and oil content traits. Plant Breed., 124: 111-15.

Srivastava, K. and B. Rai, 1997. Expression of heterosis for yield and its attributes in rapeseed (*Brassica napus*). Indian J. Agric. Sci., 63: 243-245.

Starmer, K.P., J. Brown and J.B. Davis, 1998: Heterosis in spring canola hybrids grown in Northern Idaho. Crop Sci., 38: 376-380.

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

Teklewold A. and H.C. Becker, 1991. Heterosis and combining ability in a diallel cross of Ethiopian mustard inbred lines. Crop Breed., 10: 21-35.

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.