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Heterosis and inbreeding depression for yield and its components in Indian mustard

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Heterosis and inbreeding depression were studied in 45 hybrids developed through 10 X 10 diallel set of Indian mustard [*Brassica juncea* (L.) Czern & Coss.]. Heterobilities varied from - 21.4 to 19.6 per cent and standard heterosis from - 23.6 to 29.6 per cent for seed yield. Significant desirable heterosis over best parent (Rohini) was observed for all the characters studied. Maximum significant standard heterosis was observed for main shoot length (56.6%) followed by secondary branches (35.8%), seed yield (29.6%), siliquae on main shoot (28.6%), seeds per siliqua (23.4%) and primary branches (22.4%) while heterobeltosis for main shoot length (68.7%), secondary branches (49.8%), siliquae on main shoot (41.6%), seeds per siliqua (39.1%), primary branches (33.4%) and seed yield (19.6%). The inbreeding depression for seed yield ranged from - 35.2 to 12.8 per cent. The highest significant positive heterobeltosis and standard heterosis and high inbreeding depression was recorded in hybrids Rohini X Varuna followed by RK 9870 X Vardan and Rohini X Vardan for seed yield. These crosses may be utilized for developing hybrids.

Key words : Heterosis, Inbreeding depression, GCA effects, SCA effects, Mustard.

INTRODUCTION

Mustard is predominantly a self - pollinated crop and the exploitation of hybrid vigour will depend upon the direction and magnitude of heterosis, biological feasibility, and nature of gene action involved. Heterosis denotes the increased desired vigour in F_1 arising due to recombination, inter and intra-allelic interactions, complementation and accumulation of desired gene complexes in F_1 from parent whereas, the inbreeding depression reflects the change in vigour of F_1 into F_2, which is largely due to segregation, linkage, etc. and ultimately the vigour obtained in F_1 is diversified. However, the manifestation of heterosis in F_1 and inbreeding depression in F_2 jointly in combination signifies the nature of gene action involved for the expression of the vigour in F_1 and depression in F_2. As the high heterosis with least inbreeding depression depicts involvement of largely additive gene action, high heterosis coupled with high inbreeding depression refers the involvement of non-additive gene action. Thus, the heterosis and inbreeding depression are good indicator for the understanding of gene action without any complicated analysis. With the availability of perfect restoration for moricandia CMS (Prakash *et al.*, 1998), heterosis breeding is being looked as a promising tool to over come the yield barriers in Indian mustard (Pandey *et al.*, 1999), which is a predominant oil seed crop of Indian subcontinent. The present investigation was undertaken to estimate the level of heterosis and inbreeding depression from crosses of diverse genotypes of Indian mustard.

MATERIAL AND METHODS

The experimental material comprising of ten diverse genotypes of Indian mustard viz., RK 8605, RK 9803, RK 9807, RK 9808, Mathura Rai, NDR-8501, Rohini, Vardan, Basanti and Varuna. These parents have been maintained by self - pollination for several generations and therefore, may be considered as homozygous. An experiment comprising 100 treatments (45 $F_{1\,S}$, 45 $F_{2\,S}$ and 10 parents) was conducted in Randomised Block Design with three replications during *Rabi* 2002-2003 at Oilseeds Research farm, Kalyanpur, Kanpur of C.S. Azad University of Agriculture and Technology, Kanpur. Each parent and $F_1'_S$ were grown in single row and each $F_2'_S$ in two rows of five metre length spaced at 45 cm apart. All recommended agronomic practices were adopted. Ten plants in $F_1'_S$ and twenty plants from each $F_2'_S$ were randomly selected for recording the observations on eleven characters (Table 1). The F_1 hybrid performance was computed as the estimates of heterosis over Rohini (heterobeltosis) and over Varuna (standard heterosis). Heterosis and inbreeding depression were calculated in percentage, using the standard procedures.

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RESULTS AND DISCUSSION

Highly significant differences were observed amongst genotypes for the characters studied. In general, the range for most of the characters was wider in hybrids than their parent (Table 1). The magnitude of heterobeltosis varied from cross to cross and from character to character. This indicated the existence of potential heterosis in Indian mustard. Highest extent of heterobeltosis (68.7%) was observed for main shoot length. Secondary branches also exhibited high extent of heterobeltosis (49.8%). Among the remaining characters viz., seed yield, primary branches, siliquae on main shoot, seeds per siliqua and plant height also showed good amount of both heterobeltosis, while days to flower and days to maturity exhibited poor heterosis. Confirming the above findings significant heterosis were reported by Pradhan *et al.* (1993), Khulbe *et al.*, (1998 b) and Chauhan *et al.* (2000) for primary branches, secondary branches and seed yield in Indian mustard. None of the cross exhibited heterosis for test weight and oil content. It is expected oil content is being governed predominantly by additive gene action. Absence of heterosis for test weight may be due to balancing the positive and negative genes. Similarly desired inbreeding depression were also observed for seed yield and its component characters, except test weight and oil content in Indian mustard. Significant inbreeding depression for seed yield in Indian mustard has also been reported by Thakur and Bhateria (1993). The maximum inbreeding depression was recorded for siliquae on main shoot (32.2%) followed by main shoot length (25.4%) and secondary branches (22.7%).

Significant negative heterobeltosis and standard heterosis along with positive inbreeding depression were recorded for days to flower, days to maturity and plant height which is desirable for development of early and dwarf types. The crosses showing maximum heterosis and inbreeding depression with respect to each of these characters are presented in Table 2. Hybrid RK 9807 X Rohini exhibited highest significant negative heterobeltosis for days to flower and days to maturity. Similarly, cross Mathura Rai X Rohini showed maximum significant heterobeltosis for plant height. RK 9807 which has the lowest mean value for days to flower and days to maturity, while Mathura Rai has the lowest mean value for plant height over the standard check Varuna. The inclusion of these promising crosses is advocated in breeding programmed aimed at developing varieties for early and dwarf types.

The crosses exhibited heterobeltosis from - 21.4 to 19.6 per cent, and inbreeding depression - 35.2 to 12.8 per cent for seed yield. Fifteen crosses showed significant positive heterobeltosis and twelve crosses showed significant positive standard heterosis for seed yield. Cross Rohini X Varuna was noticed for significant positive standard heterosis for seed yield, primary branches, secondary branches, main shoot length, siliquae on main

Table 1 : Range of heterosis and inbreeding depression for various characters in Indian mustard.

Character	Range				
	Parents	Hybrids	Heterobeltosis	Standard heterosis (%)	Inbreeding depression (%)
Days to flower	35.6-56.7	37.8-61.9	-7.8-16.6 3)	-8.8-6.3 (6)	-9.2-6.5 (6)
Days to maturity	106.5-137.6	105.3-145.2	-3.6-12.5 (3)	-2.9-5.2 (4)	-8.5-8.4 (8)
Plant height	140.6-179.5	145.6-195.4	-9.6-27.3 (10)	-12.4-7.8 (5)	-21.4-9.5 (4)
Primary branches	3.4-6.2	3.8-7.6	-35.6-33.4 (13)	-33.6-22.4 (9)	-25.6-19.4 (7)
Secondary branches	7.3-12.2	7.6-13.8	-59.6-49.8 (11)	-39.3-35.8 (12)	-36.4-22.7 (10)
Main shoot length	30.4-52.9	28.5-61.5	-46.3-68.7 (18)	-27.2-56.6 (14)	-42.6-25.4 (12)
Siliquae on main shoot	16.9-32.8	17.6-39.4	-24.7-41.6 (17)	-21.4-28.6 (13)	-38.4-34.2 (11)
Seeds per siliqua	10.7-14.5	11.2-16.9	-32.2-39.1 (20)	-22.3-23.4 (17)	-25.1-16.4 (15)
Seed yield per plant	13.5-23.3	16.2-30.5	-21.4-19.6 (15)	-23.6-29.6 (12)	-35.2-12.8 (9)
Test Weight	3.2-5.2	3.5-5.4	-12.3-1.9	-11.8-1.6	-16.4-5.2
Oil content	37.6-41.5	38.0-41.8	-8.5-1.6	-8.2-1.3	-6.6-4.3

Figures in parentheses indicate the number of significant heterobeltosis, standard heterosis and inbreeding depression (at P > 0.05 and P > 0.01) in the desired direction.

Table 2 : Best crosses showing maximum heterosis (%) and inbreeding depression (%) for various characters in Indian mustard.

Character	Heterobeltosis		Standard Heterosis		Inbreeding depression	
Days to flower	-7.8**	(RK 9807 X Rohini)	-8.8**	(RK 9807 X Rohini)	6.5**	(RK 9808 X Vardan)
	-6.5**	(RK 9807 X Basmati)	-7.6**	(RK 9808 X Rohini)	5.8**	(RK 9807 X Varuna)
Days to maturity	-3.6**	(RK 9807 X Rohini)	-2.9**	(RK 9807 X Rohini)	8.4**	(RK 9808 X Vardan)
	-3.4**	(RK 9808 X Rohini)	-2.8**	(RK 9807 X RK 9808)	8.2**	(RK 9808 X Varuna)
Plant height	9.6**	(Mathura Rai X Rohini)	-12.4**	Mathura Rai X Rohini	9.5**	(RK 9802 X Varuna)
	-8.5**	(Mathura RaiXRK 9808)	-11.6**	(Mathura Rai X RK 9807)	8.6**	(RK 9808 X Vardan)
Primary branches	33.4**	(RK 9803 X Basanti)	22.4**	(Varuna X Vardan)	19.4**	(RK 9808 X Vardan)
	28.4**	(NDR 8501 X Rohini)	20.6**	(Rohini X Varuna)	18.6**	(RK 9808 X Vardan)
	27.6**	(RK 9807 X Vardan)	19.3**	(Varuna X NDR 8501)	16.7**	(RK 9808 X Varuna)
Secondary branches	49.8**	(RK 9803 X Basanti)	35.8**	(Vardan X Varuna)	22.7**	(RK 9808 X Varuna)
	42.6**	(RK 9803 X Rohini)	26.2**	(Rohini X Varuna)	18.3**	(RK 9807 X Varuna)
	36.4**	(Vardan X Varuna)	24.3**	(Vardan X Basanti)	16.5**	(Vardan X Basanti)
Main shoot length	68.7**	(Rohini X RK 9808)	56.6**	(Rohini X Varuna)	25.4**	(Rohini X Varuna)
	56.7**	(Rohini X Basanti)	52.6**	(Rohini X RK 9808)	25.2**	(Rohini X RK 9807)
	55.4**	(Rohini X RK 8605)	45.2**	(Rohini X RK 9808)	24.8**	(Vardan X Basanti)
Siliquae on main shoot	41.6**	(Rohini X RK 9808)	29.6**	(Rohini X Varuna)	34.2**	(Rohini X Varuna)
	36.2**	(Rohini X RK 9807)	26.3**	(Rohini X Vardan)	33.6**	(Rohini X Vardan)
	32.6**	(Vardan X Varuna)	22.4**	(Vardan X Varuna)	28.4**	(Vardan X Varuna)
Seeds per siliqua	39.1**	(RK 9807 X Varuna)	23.4**	(RK 9807 X Varuna)	16.4**	(RK 9807 X Varuna)
	38.4**	(RK 8605 X Rohini)	20.2**	(Rohini X Varuna)	15.8**	(Rohini X Varuna)
	36.5**	(Rohini X Vardan)	18.6**	(Rohini X Vardan)	15.5**	(Rohini X Vardan)
Seed yield per plant	19.6**	(Rohini X Varuna)	29.6**	(Rohini X Varuna)	9.5**	(Rohini X Varuna)
	18.8**	(RK 9807 X Vardan)	28.4**	(RK 9807 X Vardan)	9.4**	(RK 9807 X Vardan)
	18.4**	(Rohini X Vardan)	28.2**	(Rohini X Vardan)	8.9**	(Rohini X Vardan)

** P > 0.01

shoot and seeds per siliqua. With regard seed yield, not all the crosses showing heterosis for one or more yield components ended up with high seed yield heterosis, suggesting that heterosis in the complex character is not due to manifestation of heterosis in all of its component characters. In some cases, heterosis in one component alone contributed heterosis for seed yield as in RK 9807 X Vardan in which showed heterobeltosis only primary branches. Significant high standard heterosis (>22%) and heterobeltosis (>15%) were observed in the crosses

Table 3 : Cross selected on the basis of heterosis, inbreeding depression and along with sca and gca effects for seed yield.

Crosses		Heterosis (%)		Inbreeding depression (%)	sca effects		gca effects	
		Heterobeltosis	Standard heterosis		F1	F_2	F1	F_2
Rohini	X Varuna	19.6**	29.6**	9.5**	6.5**	-5.8**	H X L	H X L
RK 9807	X Vardan	18.8**	28.4**	9.4**	4.6**	2.8**	L X H	L X H
Rohini	X Vardan	18.4**	28.2**	9.2**	5.3**	1.9**	H X L	H X L
RK 9807	X Vardan	17.3**	25.7**	5.7**	2.8**	4.3**	H X L	H X M
RK 9803	Rohini	15.4**	22.4**	5.8**	2.6**	2.9**	H X L	H X H

** P > 0.01

Rohini X Varuna, RK 9807 X Vardan, Rohini X Vardan, RK 9807 X Varuna and RK 9803 X Rohini. Among these crosses, Rohini X Varuna, RK 9807 X Vardan and Rohini X Vardan exhibited standard heterosis 29.6, 28.4 and 28.2 per cent while heterobeltosis was observed 19.6, 18.8 and 18.4 per cent and high inbreeding depression, respectively (Table 3). It indicates that in above crosses exhibiting high heterosis and high inbreeding depression coupled with high sca effects and involved most of the parent in high X low gca effects combinations indicated the cause of heterosis in F_1 ie. non additive (non-fixable) gene action which directs the exploitation of these crosses as single cross hybrids. However, remaining two crosses viz., RK 9807 X Varuna and RK 9803 X Rohini though exhibited high heterosis along with meagure inbreeding depression where as, sca effects were significantly high and involved high X medium and high X high gca effects combinations in F_2. This phenomenon indicates that in F_2 non-additive gene action funnelled out considerably and approaching to the additiveness, thus these crosses are required to be subjected to the pedigree/progeny selection directly, otherwise biparental mating, thereafter progeny/ pedigree method of selection of transgressive segregants of high yielding recombinants coupled with desired attributes may be selected for further use as cultivars.

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