Journal of Oilseed Brassica, 7 (2) : 180-185, July 2016

Evaluation of the heterotic potential for seed yield and its attributing traits in Indian mustard (B*rassica juncea* L.)

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(*Received: 4 April 2016: Revised: 12 May 2016; Accepted: 27 June 2016*)

Abstract

Heterotic potential for seed yield, and yield components in Indian mustard was studied using line × tester analysis involving three lines, and twenty testers for fourteen characters including seed yield, its components, and quality characters. Number of crosses exhibiting significant positive heterosis, heterobeltiosis, and economic heterosis for seed yield per plant were 9, 4 and 3, respectively. Three crosses depicted significant positive heterotic effect for seed yield per plant, *viz.,* GM-2 x PYM-7, GM-3 x PAB-9511 and GM-3 x NUDH-45-1. Among these crosses, GM-2 x PYM-7, and GM-3 x PAB-9511 also exhibited significant and desirable heterotic effect for numbers of siliquae per plant, primary branches per plant and secondary branches per plant. Hence, could be further evaluated in heterosis breeding programme, and simultaneously advanced in segregating generations to obtain desirable segregants for the development of superior genotypes.

Key words: *Heterosis, heterobeltiosis, Indian mustard, line × tester*

Introduction

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is an important *Rabi* season oilseed crop in India with a premier position among the oilseed crops. It is popularly known as *rai*, *raya* or *laha* in India with an area of 6.70 million hectares with 7.96 million metric tonnes, and 1188 kg/ha as production, and productivity respectively (Anonymous, 2014). This crop ranks second in area, and third in production. Improving yield, and oil content are the major breeding objectives in case of mustard. Heterosis breeding approach is one of the most successful breeding options being employed for the improvement of crop varieties. 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 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 was estimated for maturity, and some important agronomic traits in F_1 generation of mustard genotypes using 3 x 20 LxT cross experiment.

Materials and Methods

The experimental material comprised of three females viz., GM-1, GM-2, GM-3, twenty male parents (PYM-7, SKM-9825, NUDH-45-1, RSK-

29, PRN-393, PBR-357, B-351, AA-52, NPJ-95, RRCM-74, IC-261670, PAB-9511, SW-91-1, IC-131819, RH-8813, NRCM-120, SKM-0157, NPJ-90, SKM-9588, DIR-747), and their 60 F_1S developed by crossing three females (lines) with twenty males (testers) in a Line x Tester mating system. The seeds of 60 F1 hybrids, and 23 parents were produced by hand emasculation-hand pollination, and selfing, respectively during *Rabi* 2012-13. These 60 F_1 hybrids along with 23 parents were evaluated in randomized block design with three replications during *rabi* 2013-14 at Anand Agricultural University, Anand. This site is located at $22^0$35' North Latitude, and $72^0$55' East longitude at an elevation of 45.1 m above mean sea level. Inter and intra row spacing was kept 45 and 15 cm, respectively. All the recommended package of practices was adopted to raise a good crop.

For recording other observations, 5 competitive plants were randomly selected, and tagged for each treatment in each replication, and the average value per plant was computed for various yield, and its attributing traits *viz.*, plant height (cm), numbers of primary branches, secondary branches, effective length of main branch (cm), siliquae on main spike, siliquae per plant, siliqua length (cm), seeds per siliqua, yield per plant (g), 1000-seed weight (g), oil content (%), and protein content (%).The phenological characters *viz.*, days to flowering, and days to maturity were recorded on plot basis. Magnitude of relative heterosis, heterobeltiosis, and standard heterosis were computed as per procedure suggested by Turner (1953) Fonesca and Patterson (1968), Meredith and Bridge (1972), respectively.

Results and Discussion

The character-wise data of parents, and hybrids were subjected to analysis of variance for the experimental design. The analysis of variance revealed that mean squares due to genotypes were highly significant for all the characters (Table 1). This indicated that sufficient genetic variability was present in the materials for all the characters under study. The mean squares due to genotypes were further partitioned into parents, hybrids, and parents *vs.* hybrids. The mean square due to parents, hybrids, and parents' *vs* hybrids was highly significant for all the traits studied except variance due to parents' *vs* hybrids for number of seeds per siliquae, indicating the performance of hybrids as a group was different than that of parents for most of the characters. This revealed the presence of considerable heterosis due to directional dominance.

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, crosses exhibiting heterosis in negative direction are of immense value for earliness. Hybrid GM-2 x AA-52 exhibited significant and maximum negative heterosis (-9.78), and heterobeltiosis (-5.30) for days to 50 % flowering (Table 2). For early maturity, GM-2 x PBR-357 (-4.79) and GM-3 x SW-91-1(-3.26) depicted significant, and maximum heterosis, and heterobeltiosis in desirable direction, respectively. While, hybrid GM-1 x NPJ-90 exhibited maximum negative significant heterosis over the standard check variety GM-3 for days to 50 % flowering (-7.54) and days to maturity (-5.93).

In brassica, short stature with vigorous structure containing more number of primary branches, secondary branches, and length of main branch provide opportunity for more yields, so positive heterosis is desirable for these traits. Hybrids GM-2 x IC-261670, and GM-2 x PYM-7 showed significant, and maximum standard heterosis for primary branches (29.7), and secondary branches (12.3), respectively. The crosses, GM-1 x DIR-747, GM-2 x NUDH-45-1, and GM-1 x IC-261670 exhibited high estimates of relative heterosis, heterobeltiosis, and standard heterosis in desirable direction for length of main branches, number of siliquae on main branch, and siliquae length, respectively.

Improvement in yield is one of the important objectives, so the superiority of hybrids over the best cultivated variety is essential for increasing its commercial value. In present study, well known variety GM-3 released by S.D. Agricultural University, Dantiwada has been used as standard check in order to obtain information on superiority of hybrids. Three most heterotic crosses for seed yield per plant along with *per se* performance, and

Table 1: Analysis of variance (mean squares) for parents and hybrids for various characters in Indian mustard

Sources of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	Length of main branch (cm)	No. of siliquae on main branch	No. of siliquae per plant	Length of siliquae	No. of seeds per siliquae	Seed yield per plant (g)	1000 seed weight (g)	Oil content (%)	Protein content (%)
Replications	2	1.22	3.13	71.00	7.30**	79.89**	58.75*	23.81*	46.00	0.50**	2.49*	5.70	0.52**	11.38**	2.44**
Genotypes (G)	82	40.33**	51.67**	454.13**	2.18**	20.71**	149.94**	53.29**	16109.95**	0.67**	3.60**	78.78**	0.78**	7.09**	4.49**
Parents (P)	22	41.98**	57.29**	506.41**	1.29**	18.87**	180.51**	65.06**	15642.09**	0.73**	4.28**	76.00**	1.44**	6.88**	4.02**
Females (F)	2	19.44**	35.11**	263.18	0.52*	25.62**	96.36**	32.22*	6352.21**	0.48**	2.08	49.17**	0.26**	1.25	7.12**
Male (M)	19	34.75**	51.98**	541.94**	1.31**	3.80**	155.13**	60.13**	10328.54**	0.78**	4.42**	49.73**	1.49**	7.77**	3.88**
(F Vs M)	1	224.47**	202.66**	317.53	2.42**	291.63**	830.98**	224.29**	135179.80**	0.22	5.95**	628.82**	2.90**	1.34	0.50
Hybrids (H)	59	39.35**	47.27**	377.57**	2.24**	19.53**	127.53**	48.97**	13909.51**	0.62**	3.41**	80.61**	0.36**	7.20**	4.43**
P Vs H	1	61.73**	188.19**	3822.25**	17.60**	130.98**	799.59**	48.69**	156226.00**	1.74**	0.078	31.80**	10.53**	5.17**	18.14**
Check Vs Hybrids	1	26.36**	0.49	315.29	0.0016	56.15**	130.32**	55.41**	25112.87**	0.007	0.028	245.58**	4.08**	1.18	1.15
Error	164	2.68	5.24	87.72	0.17	1.31	13.63	6.95	776.85	0.10	0.72	3.95	0.029	0.44	0.34

*, ** significant at 5% and 1% levels, respectively

Table 2: The range of heterosis (H_1), heterobeltiosis (H_2) and economic heterosis (H_3) and number of crosses showing significant heterosis, heterobeltiosis and economic heterosis for 14 characters in Indian mustard.

Characters	Range of heterosis and most heterotic cross			Number of hybrids having significant heterotic effect					
	H_1	H_2	H_3	H_1		H_2		H_3	
				+ve	-ve	+ve	-ve	+ve	-ve
Days to 50% flowering	-9.78 to 10.89 (GM-2 x AA-52)	-5.30 to 24.26 (GM-2 x AA-52)	-7.54 to 21.90 (GM-1 x NPJ-90)	21	7	41	1	30	4
Days to maturity	-4.79 to 4.83 (GM-2 x PBR-357)	-3.26 to 10.09 GM-3 x SW-91-1)	-5.93 to 6.53 (GM-1 x NPJ-90)	6	8	23	1	12	18
Plant height (cm)	-9.21 to 18.28 (GM-3 x NRCM-120)	-3.82 to 29.96 (GM-2 x SW-91-1)	-14.39 to 19.65 (GM-2 x NPJ-90)	21	1	37	0	22	1
No. of primary branches per plant	-23.32 to 45.35 (GM-1 x PAB-9511)	-26.73 to 35.87 (GM-1 x PAB-9511)	-26.75 to 29.72 (GM-2 x IC-261670)	25	7	12	11	12	12
No. of secondary branches per plant	-38.12 to 31.83 (GM-2 x PYM-7)	-51.10 to 17.19 (GM-1 x B-351)	-51.10 to 12.30 (GM-2 x PYM-7)	11	23	3	38	3	49
Length of main branch (cm)	-14.00 to 31.28 (GM-1 x DIR-747)	-21.79 to 27.78 (GM-1 x DIR-747)	-22.30 to 15.87 (GM-1 x DIR-747)	19	16	5	28	2	33
No. of siliquae on main branch	-19.08 to 20.50 (GM-2 x NUDH-45-1)	-22.74 to 11.73 (GM-2 x NUDH-45-1)	-22.36 to 8.29 (GM-2 x NUDH-45-1)	11	11	3	22	1	29
No. of siliquae per plant	-35.47 to 36.90 (GM-2 x SKM-0157)	-46.35 to 22.13 (GM-2 x PYM-7)	-48.33 to 14.09 (GM-2 x PYM-7)	25	18	4	31	2	45
Siliquae Length (cm)	-19.12 to 27.90 (GM-1 x IC-261670)	-22.21 to 24.93 (GM-1 x IC-261670)	-24.86 to 14.68 (GM-1 x IC-261670)	25	6	13	12	9	7
No. of seeds per siliquae	-19.52 to 17.44 (GM-1 x SKM-0157)	-20.10 to 12.44 (GM-1 x RSK-29)	-20.10 to 16.80 (GM-1 x RSK-29)	7	6	3	15	6	6
Seed yield per plant	-43.39 to 70.92 (GM-2 x PYM-7)	-58.72 to 32.42 (GM-2 x PYM-7)	-58.72 to 21.68 (GM-2 x PYM-7)	9	30	4	46	3	54
1000 seed weight	-32.28 to 0.28 (GM-3 x PBR-357)	-32.42 to -4.12 (GM-2 x DIR-747)	-35.36 to 5.89 (GM-3 x PBR-357)	0	51	0	58	1	59
Oil content (%)	-13.36 to 10.15 (GM-1 x PYM-7)	-14.86 to 7.87 (GM-3 x RRCM-74)	-14.86 to 7.87 (GM-3 x RRCM-74)	14	19	10	29	6	21
Protein content (%)	-17.08 to 11.05 (GM-1 x RH-8813)	-13.80 to 9.86 (GM-1 x RH-8813)	-15.00 to 6.36 (GM-2 x SKM-9588)	16	25	7	34	5	23

+ve = Positive   -ve = Negative   Bold letter indicate: highest heterosis value and their cross combination.

Table 3: Three most heterotic crosses for seed yield per plant along with *per se* performance and their heterotic effects for component characters in Indian mustard

Crosses	Mean seed yield per plant (g)	Relative heterosis for seed yield per plant (%)	Heterobeltiosis for seed yield per plant (%)	Standard heterosis for seed yield per plant(%)	Also desirable significant for other traits
GM-2 x PYM-7	34.5	70.9**	32.4**	21.7**	Number of primary branches per plant, number of secondary branches per plant and number of siliquae per plant.
GM-3 x PAB-9511	34.4	63.5**	21.4**	21.4**	Number of primary branches per plant, number of secondary branches per plant and number of siliquae per plant.
GM-3 x NUDH-45-1	31.9	26.9**	12.5**	12.5**	Number of primary branches per plant and number of siliquae on main branch.

*, ** Significant at 5 % and 1% levels, respectively

their heterotic effects for component characters are represent in Table 3. The highest yielding hybrid, GM-2 x PYM-7 (34.5 g) had the highest relative heterosis (70.9), heterobeltiosis (32.4), and standard heterosis (21.7) over the best check variety, GM-3. In addition, the hybrids GM-3 x PAB-9511, and GM-3 x NUDH-45-1 also exhibited high estimates of relative heterosis, heterobeltiosis, and standard heterosis for seed yield per plant. Among these crosses, GM-2 x PYM-7, and GM-3 x PAB-9511 also exhibited significant, and desirable heterotic effect for numbers of siliquae per plant, primary branches per plant, and secondary branches per plant.

However, none of the hybrids were found having significant, and positive relative heterosis, and heterobeltiosis for 1000 seed weight. In case of oil, and protein content, number of hybrids exhibiting significant positive heterosis was 14, and 16 respectively. For oil and protein content, the value for relative heterosis, heterobeltiosis, and standard heterosis were low.

On the whole, considerable heterosis, heterobeltiosis and standard heterosis was observed for seed yield, and other associated characters which suggested the presence of large genetic diversity among the males, and the females, and also the unidirectional distribution of allelic constitution contributing towards desirable heterosis in the present material. Earlier studies by Khulbe *et al.* (1998), Agrawal and Badwal (1998), Kumbhalkar *et al.* (2000), Sheikh and Singh (2001), Ghosh *et al.* (2002), Singh *et al.* (2003), Rai and Verma (2005), Macwana (2008), Gupta *et al.* (2011), Dholu *et al.* (2014), and Niranjana *et al.* (2014) also revealed heterosis in desirable direction for various characters in Indian mustard.

Low magnitude of relative heterosis, heterobeltiosis, and standard heterosis were observed for some of the characters *viz.*, 1000 seed weight, oil content, and protein content indicated the narrow genetic base among the males, and females, and also ambidirectional distribution of allelic cinstitution contributing towards undesirable heterosis or may be due to mutual cancellation of effect of dominant alleles present in the materials. Similar results were also noticed by Singh *et al.* (2003), Macwana (2008), Dholu *et al.* (2014), and Niranjana *et al.* (2014).

It is clear from the above discussion that three crosses, GM-2 x PYM-7, GM-3 x PAB-9511, and GM-3 x NUDH-45-1 were found to be most promising for seed yield, and other desirable traits, hence could be further evaluated in heterosis breeding programme, and simultaneously advanced in segregating generations to obtain desirable segregants for the development of superior genotypes.

Acknowledgements

The first author is thankful to Anand Agricultural University for providing a great scope for study on Indian mustard and also thankful to Dr. N. Sasidharan along with other staff members for providing assistance in my research.

References

Agarwal PK, Badwal SS. 1998. Possible utilization of commercial heterosis in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]. *Indian J Agric Res* **58**: 513-516.

Anonymous. 2014. Ministry of Agriculture, Govt. of India, <www.indiastat.com>

Dholu VK, Sasidharan N, Suthar K, Bhushan B, Patel JN. 2014. Heterosis and combining ability in Indian mustard (*B. juncea* L.). *Intl J Agric Sci* **10**: 102-107.

Fonesca S, Patterson FL. 1968. Hybrids vigour in a seven parent diallel cross in common winter wheat (*Triticum aestivum* L.). *Crop Sci* **8**: 85-95.

Ghosh SK, Gulati SC, Rajani Raman, Raman R. 2002. Combining ability and heterosis for seed yield and its components in Indian mustard [*B. juncea* (L.) Czern & Coss.]. *Indian J Genet* **62**: 29-33.

Gupta Priti, Chaudhary HB, Lal SK. 2011. Heterosis and combining ability analysis for yield and its components in Indian mustard [*B. juncea* (L.) Czern & Coss.]. *Acad J Plant Sci* **4**: 45-52.

Hassan G, Mohammad F, Khalil FH, Raziuddin. 2006. Heterosis and heterobeltiosis studies for morphological traits in bread wheat. *Sarhad J Agri* **22**: 51-54.

Khulbe RK, Pant DP, Rawat RS. 1998. Heterosis for yield and its components in Indian mustard. *J Oilseeds Res* **15**: 227-230.

Kumbhalkar HB, Dawande VB, Nair B, Patil S. 2000. Heterosis breeding in mustard. *J Oilseeds Res* **17**: 354-355.

Macwana SS. 2008. Genetic analysis of seed yield and its attributes in Indian mustard [*B. Juncea* (L.) Czern & Coss.] over environments. PhD (Agri) Thesis submitted to Dept. of Plant Breeding, AAU, Anand.

Meredith WR, Bridge RR. 1972. Heterosis and gene action in cotton, *G. hirsutum* L. *Crop Sci* **12**: 304-310.

Niranjana M, Akabari VR, Sasidharan N, Jadeja GC. 2014. Diallel analysis for yield and its contributing characters in Indian mustard [*B. juncea* (L.) Czern & Coss.]. *Electronic J Pl Breed* **5**: 197-202.

Pal BP, Sikka SM. 1956. Exploitation of hybrid vigour in the improvement of crop plants, fruits and vegetables. *Indian J Genet Plant Breed* **16**: 95-193.

Rai SK, Verma A. 2005. Heterosis study in Indian mustard *[B. juncea* (L.) Czern & Coss.]. *Indian J Genet* **65**: 217- 218.

Sheikh IA, Singh JN. 2001. Heterosis in Indian mustard hybrids derived using male sterile lines for yield and component characters. *Crop Res* **21**: 198-203.

Singh AK, Singh B, Sachan JN. 2003. Diallel analysis for combining ability for yield and its component including oil content in Indian mustard. *J Oilseeds Res* **21**: 269-271.

Turner JH. 1953. A study of heterosis in upland cotton, combining ability and inbreeding effects. *Agron J* **45**: 487-490.