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HETEROSIS AND INBREEDING DEPRESSION IN INDIAN MUSTARD

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ABSTRACT

Thirty three mustard (*Brassica juncea*) hybrids derived from crosses of eleven lines and three testers along with their F_1, F_2 and parents were evaluated to estimate heterosis, inbreeding depression and combining ability. Manifestation of heterosis was maximum for secondary branches per plant and minimum for primary branches per plant. In general, high heterosis for a trait was accompanied by significant inbreeding depression. The estimates of sca were greater than the gca for yield and its components. The use of at least one, preferably both, good general combiners in a particular cross for the trait under consideration was advocated. Based on these results it is suggested that heterotic response, level of inbreeding depression and gca effects of the parents, if considered together, can be helpful in identification of crosses which are likely to yield better performing pure lines by applying suitable breeding procedures.

Key words: Heterosis, inbreeding depression, combining ability, Indian mustard.

Mustard is predominantly a self-pollinated crop and the scope for exploitation of hybrid vigour will depend upon the direction and magnitude of heterosis, biological feasibility and the type of gene action involved. A dynamic breeding programme involving parents with diverse genetic backgrounds requires thorough evaluation of the breeding materials so as to identify the potentially productive crosses. Many reports have appeared on the heterosis for yield and its components in Indian mustard [1–4]. However, in order to isolate desirable crosses, it is imperative to have prior information about heterosis, inbreeding depression and nicking ability of the parents involved. The present investigation is an attempt in this direction.

MATERIALS AND METHODS

Eleven agronomically desirable lines of Indian mustard (TM4, TM21, DIRA367, DIRA-329, DIRA-128, RSM-123, RH-8554, RH-30, RFD-3, PR-8603 and PR-8605) were crossed with three well adapted male parents (Varuna, Krishna and RLM-619). Fourteen parents and 33 each of F_1 and F_2 were raised in completely randomized block design replicated thrice, with one row of each parent and F_1 and six rows of each F_2. The row length was 3 m with row-to-row and plant-to-plant distance of 30 and 10 cm, respectively. Data on five competitive plants per plot in each parent and F_1, and 20 plants in each F_2 were recorded for primary branches per plant, secondary branches per plant, siliquae per mother shoot, siliquae per plant, seeds per siliqua, and yield per plant. The combining ability analysis was done following the Griffing's Model 1 and Method 2 [5]. Heterosis was calculated as percentage deviation from mean value of F_1 over the better parent (BP). Inbreeding depression was calculated as per cent depression from F_1 mean to F_2 means.

RESULTS

The magnitude of positive heterosis was higher than negative heterosis for all the characters studied (Table 1). Average heterosis was maximum for primary branches per plant. The highest (16) and the lowest (8) number of crosses, exhibiting heterosis higher than average heterosis, were observed for secondary branches per plant and siliquae per mother shoot, respectively.

Table 1. Heterotic response for yield and ancillary characters in 33 mustard hybrids

Heterotic response	Primary branches per plant	Secondary branches per plant	Siliquae per mother shoot	Siliquae per plant	Seeds per siliqua	Yield per plant
Range	–18.2–35.3	–34.2–169.6	–15.4–39.9	–18.1–143.9	–11.7–43.0	–28.0–138.9
Mean	10.7	52.5	23.1	41.1	12.5	43.7
No. of crosses with BP heterosis above average	10	16	8	11	9	13

The per se performance of the five top yielding hybrids in respect of yield and its components is presented in Table 2. Hybrid PR-8605 x RLM-619 was the highest yielder, followed by RFD-3 x Krishna, PR-8605 x Krishna, TM-4 x Krishna, and PR-8605 x Varuna. The highest and second highest yielding crosses also maintained their ranks in respect of secondary branches and siliquae per plant. The magnitude of BP heterosis for yield among these crosses ranged from 13.8-112.2% (Table 3) and the increases were significant and combined with significant and positive inbreeding depression. Similar results were also observed for siliquae per mother shoot, siliquae per plant, and secondary branches per plant.

All the top yielding crosses exhibited significant and positive heterosis and inbreeding depression for primary branches per plant, except the hybrid PR--8605 x Krishna which showed neither heterotic superiority nor inbreeding depression. None of the five hybrids

Table 2. Per se performance of five top high yielding hybrids in Indian mustard

Cross	Primary branches per plant	Secondary branches per plant	Siliquae per mother shoot	Siliquae per plant	Seeds per siliqua	Yield per plant (g)
PR 8603 x Varuna	4.5	8.9	44.6	279.1	14.1	11.7
PR 8603 x RLM 619	5.1	13.3	54.4	388.8	12.3	18.7
TM 4 x Krishna	4.5	10.5	48.3	222.0	11.4	12.0
PR 8605 x Krishna	3.9	9.4	55.7	273.2	12.5	13.0
RFD 3 x Krishna	4.3	12.4	46.7	283.4	13.0	14.3

displayed significant heterosis for seeds per siliqua, however, significant inbreeding depression was observed in the cross RFD-3 x Krishna for this trait.

The analysis of combining ability (Table 4) showed that mean square due to lines and testers were significant for secondary branches per plant, siliquae per mother shoot and siliquae per plant. Mean square due to line x tester interactions were significant for secondary branches per plant, siliquae per mother shoot, siliquae per plant, and yield per plant. Lines RH-30 and PR-8603 and tester Krishna showed significant and positive gca effects for yield and siliquae per plant.

DISCUSSION

The present investigation provides information on the evaluation of mustard hybrids and their parents through the estimates of heterosis, inbreeding depression and combining ability. Thirty three hybrids derived from crosses between eleven lines and three testers were analysed for yield and its components. However, exploitation of heterosis is considered meaningless unless per se performance is also taken into account. Accordingly, detailed analysis of five top yielding hybrids was carried out for having an insight into the nature of gene action.

Higher estimates of heterosis were recorded for yield. Maximum economic heterosis was expressed by the cross PR-8603 x RLM-619 (112.2%), followed by PR 8603 x Varuna (51.5%). Further, heterotic hybrids for seed yield also showed significant and positive heterosis for majority of yield components studied except for seeds per siliqua in all the five crosses and primary branches per plant in the cross PR 8605 x Krishna.

Heterosis in F_1 and inbreeding depression in F_2 considered together can give some idea about the genetic control of a character and thus helps in isolating high yielding pure lines

Table 3. Better parent (BP) heterosis, inbreeding depression (ID) and parental gca (P) for yield and its components in five top yielding hybrids in mustard

Character	PR 8603 x Varuna	PR 8603 x RLM 619	TM 4 x Krishna	PR 8603 x Krishna	RFD 3 x Krishna
Primary branches per plant:					
BP	23.8*	18.5*	21.9*	7.4	35.8**
ID	28.7*	31.8*	26.0**	15.3	27.7**
P	H x L	H x L	L x L	L x L	L x L
Secondary branches per plant:					
BP	94.1**	79.3**	112.7**	119.3**	169.6**
ID	33.4**	31.9**	30.7**	46.8**	54.4**
P	H x L	H x H	H x L	H x L	L x L
Siliquae per mother shoot:					
BP	25.8**	19.5**	28.3**	48.0**	31.5**
ID	11.7	29.2**	23.2*	28.4*	18.3*
P	L x H	L x L	L x H	H x H	L x H
Siliquae per plant:					
BP	143.9**	98.7**	13.3	39.4**	104.5**
ID	44.5**	60.0**	40.5**	53.5**	52.9**
P	H x H	H x L	L x L	H x L	L x L
Seeds per siliqua:					
BP	9.9	-9.4	-9.0	9.3	1.1
ID	2.8	-7.1	-8.8	6.4	21.0*
P	H x L	H x L	L x L	H x L	L x L
Yield per plant:					
BP	51.5**	112.2**	36.4*	47.7**	13.8*
ID	56.0**	60.5**	46.4**	49.8**	56.0**
P	H x H	H x L	H x H	L x L	L x H

L—low gca; H—high gca.

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

from the promising crosses. An examination of data on inbreeding depression for seed yield per plant and other characters indicated that, in general, mean expression of F_2 was lower than that of F_1, may be largely due to dominance and epistatic interactions involving dominance. Isolation of true breeding lines, as good as or better than the heterotic hybrids, may be a difficult proposition in such crosses unless special breeding methods like recurrent selection, diallel selective mating etc. are employed. Parallel relationship between heterosis in F_1 and inbreeding depression in F_2 [1, 2, 6–9] suggested the importance of nonadditive gene action for controlling the characters.

Table 4. Analysis of variance of combining ability (mean square) for yield and some ancillary characters in F_1 of Indian mustard

Source	d.f.	Primary branches per plant	Secondary branches per plant	Siliquae per mother shoot	Siliquae per plant	Seeds per siliqua	Yield per plant
Lines	10	0.53	16.9*	18.5	12014.7*	7.73	19.5
Testers	2	0.52	16.7*	180.7	5599.1*	5.80	44.9*
Line x tester	20	0.50	13.5**	73.3**	241407.6**	3.83	14.6**

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

Significant economic heterosis without inbreeding depression for seed yield and siliquae per plant in the cross DIRA 329 x Varuna (other than five top yielding) implied that mostly additive type epistatic interactions may be involved in this case. Such crosses have the potential to generate desirable recombinants in the segregating generations which can be handled through pedigree breeding method. Among all the crosses, the F_1 did not deviate significantly from the better parent in respect of seeds per siliqua and primary branches per plant only in the cross PR-8605 x Krishna, suggesting the presence of favourable genes with additive effects for these characters.

The estimates of sca variances were higher than the corresponding estimates of gca for seed yield and its components as observed by others in Indian mustard [3, 4]. Depending on the gca effects of parents for a particular character, they were categorised as good or poor combiners. Interestingly, three out of five top yielding hybrids involved high x low combinations and two crosses, namely PR 8603 x Varuna and TM-4 x Krishna, included both parents as good combiners for yield and majority of its components. None of the cross combinations in the present experiment was desirable for all the yield attributing traits simultaneously. Multiple crossing programme among these top yielding hybrids, followed by relative intermating approach appears to be the most appropriate for the best use of the present material aimed at further genetic upgradation of the crop. Further, at least one, preferably both, parents of a cross should be good general combiners. Such a programme is likely to be effective in bringing together the additive genes fixable through selection.

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