EXPLOITATION OF HETEROSIS USING CYTOPLASMIC MALE STERILITY SYSTEM IN INDIAN MUSTARD [BRASSICA JUNCEA (L.) CZERN & COSS.].

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KEYWORDS
Cytoplasmic male sterility (CMS)
Heterosis
Standard variety
Indian mustard
Seed yield
To exploit heterosis, two CMS lines were crossed with thirty genotypes (testers) of Indian mustard in line x tester mating design, resulting in 60 hybrids. These thirty two parents (2 + 30) and 60 crosses were used to estimate heterosis over two standard varieties viz., Kranti (Standard Variety) and Maya (Standard variety). The variances due to ‘lines x testers’ showed highly significant differences for all the thirteen characters except harvest index indicating the predominant role of non-additive gene action in the inheritance of characters, studied. Sixty crosses used to estimate significant standard heterosis for seed yield and other metric traits revealed that the highest standard heterosis for seed yield was observed in CMSMori x NPJ-135 (13.17 %) over Kranti followed by CMSNDRE-4 x PRE 2007-06 (12.83 %) over Maya. These two hybrids were showed high magnitude of heterosis may be exploits commercial hybrid seed production by the use of advance restorer lines.

**ABSTRACT**

Indian government has encouraged the cultivation of different oilseed crops in the country to save foreign exchange. Its oil is one of the major edible oils in Indian subcontinent where it is mainly used for edible purposes, hair oil and lubricants. For developing a hybrid, as a first step information available on genetic analysis of important characters is collected. This information is 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. Exploitation of cytoplasmic male sterility in respect hybrid development could be potential method in the heterosis breeding. In order to understand the influence of cytoplasm that, how this might be affecting heterosis and combining ability and to establish which of the male sterile lines would be more suitable for use in the hybrid programme, the present line x tester was conducted. Besides, the objective was to identify the desirable, potential parents among the promising culture for transfer of restorer genes and to establish the best specific combinations for heterosis breeding. The exploitation of heterosis in Indian mustard has been limited due to its autogamous nature. For a successful hybrid breeding programme, it is essential that a significant heterosis must be available in the F₁ populations and that a method is available for commercial seed production economically. Significant level of heterosis with respect to seed yield and its component traits has been reported with hybrids showing greater advantage under adverse environmental conditions. Significantly more than 20 % heterosis has been recorded in Indian mustard (Labana et al., 1975; Gupta, 1976; Banga and Labana, 1984a; and Dhillon et al., 1990). Specific combining ability for various traits involved combinations of H x H and H x L indicating the importance of additive as well as non-additive gene action (Singh et al., 2012). The desirable sca effects may not be of practical utility until and unless per se performance of the combinations is compared to that of respective standard varieties (SV₁) and (SV₂). In pursuance to this objective, estimates of heterotic responses as well as response relative to standard varieties Kranti and Maya were computed for all the characters in different cross combinations.

**MATERIALS AND METHODS**

**Plant material and experimental detail**

The experiment was conducted at Research Farm of genetics and Plant Breeding of N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during Rabi 2011-12 of each row with 5 meters length having row to row and plant to plant distance at 45 cm and 15 cm, respectively. A total of 92 entries including check (60 F₁’s + 2 lines + 30 testers) were evaluated in randomized block design with three replications. CMS system were used in this studied having Mori candia genetic background.

**Traits measurement**

Data were recorded on five randomly selected plants leaving border plants in each replication for days to 50 per cent flowering, days to maturity, plant height (cm),
number of primary branches per plant, number of secondary branches per plant, length of main raceme (cm), number of siliquae on main raceme, number of seeds per silique, 1000-seed weight (g), biological yield (g), harvest Index (%), oil content (%) and seed yield per plant (g). The oil content was estimated by NIR on dry seed basis.

Statistical analyses

The data recorded were subjected to ‘line x tester’ analysis for combining ability (Kempthorne, 1957) and standard heterosis (Fonseca and Patterson, 1968). The design L x T, become a common practice of the plant breeder working with crop plants to obtain genetic information from the cross progenies. It is also 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.

RESULTS AND DISCUSSION

Analysis of variance for line x tester mating design is presented in Table 1. The differences among treatments were highly significant for the characters namely days to (50%) flowering, days to maturity, plant height, length of main raceme, number of siliquae per plant, number of primary branches per plant, number of secondary branches per plant, number of seeds per siliqua, oil content, test weight and seed yield per plant (Kumar et al., 2013). Further partitioning of treatment variances into parents and crosses revealed highly significant differences among parents as well as crosses for all the characters except number of primary branches per plant. Variance due to parents vs crosses was also highly significant for all characters except biological yield. Variances due to lines vs testers were highly significant for days to 50 per cent flowering, days to maturity, plant height, biological yield and oil content. However, significant differences were found for number of primary branches per plant and number of secondary branches per plant.

Present investigations were planned to find out outstanding hybrids with respect to their heterotic response as well as good specific combining ability for further yield improvement programme. Analysis of variance revealed the presence of significant variability among all the traits, studied. In case of seed yield per plant, magnitude of heterosis from -31.10 (CMSMori x NML-100) to 13.17 per cent (CMSMori x NPJ-135) over SV 1 (Kranti) and -31.31 (CMSMori x NML-100) to 12.83 per cent (CMSMori x NPJ-135) over SV 2 (Maya). The crosses showing maximum heterosis for seed yield over SV 1 were, CMSMori x NPJ-135 (13.17 %) and CMSNDRE-4 X PRE 2007-06 (11.75 %) as well as over SV 2 was CMSMori x NPJ-135 (12.83 %). Manifestation of high amount of heterosis for seed yield due to presence of substantial parental diversity at genetic level. Higher magnitude of heterotic response for seed yield in Indian mustard is also found by Gupta and Narayan

<table>
<thead>
<tr>
<th>Characters</th>
<th>Source of variation</th>
<th>Replication</th>
<th>Parents vs crosses</th>
<th>Crosses</th>
<th>Lines</th>
<th>Testers</th>
<th>Line vs testers</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to 50% flowering</td>
<td>2</td>
<td>31</td>
<td>1</td>
<td>59</td>
<td>1</td>
<td>29</td>
<td>1</td>
<td>182</td>
</tr>
<tr>
<td>Days to maturity</td>
<td>4.92*</td>
<td>84.91**</td>
<td>6.75**</td>
<td>51.51**</td>
<td>0.17</td>
<td>90.26**</td>
<td>14.62**</td>
<td>1.28</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>2.55</td>
<td>488.67**</td>
<td>17468.00**</td>
<td>748.72**</td>
<td>48.57</td>
<td>455.67**</td>
<td>1885.95**</td>
<td>29.88</td>
</tr>
<tr>
<td>No. of primary branches per plant</td>
<td>0.31</td>
<td>0.30</td>
<td>34.39**</td>
<td>0.55**</td>
<td>0.01</td>
<td>0.27</td>
<td>1.59*</td>
<td>0.24</td>
</tr>
<tr>
<td>No. of secondary branches per plant</td>
<td>1.99</td>
<td>14.94**</td>
<td>177.92**</td>
<td>5.16**</td>
<td>1.32</td>
<td>15.73**</td>
<td>5.61*</td>
<td>0.87</td>
</tr>
<tr>
<td>Length of main raceme (cm)</td>
<td>16.46</td>
<td>346.37**</td>
<td>1878.96**</td>
<td>157.87**</td>
<td>48.57</td>
<td>455.67**</td>
<td>1885.95**</td>
<td>29.88</td>
</tr>
<tr>
<td>No. of siliquae per plant</td>
<td>1.80</td>
<td>81.25**</td>
<td>1331.50**</td>
<td>76.01**</td>
<td>48.34**</td>
<td>84.95**</td>
<td>6.73</td>
<td>3.30</td>
</tr>
<tr>
<td>No. of seeds per siliqua</td>
<td>2.24*</td>
<td>6.00**</td>
<td>32.66**</td>
<td>4.93**</td>
<td>1.73</td>
<td>6.31**</td>
<td>1.10</td>
<td>0.57</td>
</tr>
<tr>
<td>1000-seed weight (g)</td>
<td>0.04</td>
<td>0.95**</td>
<td>19.14**</td>
<td>2.06**</td>
<td>0.04</td>
<td>1.01**</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>Biological yield (g)</td>
<td>7.35</td>
<td>32.77**</td>
<td>0.26</td>
<td>41.57**</td>
<td>162.76**</td>
<td>33.96**</td>
<td>30.92**</td>
<td>3.04</td>
</tr>
<tr>
<td>Harvest index (%)</td>
<td>8.00**</td>
<td>11.37**</td>
<td>48.89**</td>
<td>2.13*</td>
<td>0.06</td>
<td>12.15**</td>
<td>0.39</td>
<td>1.28</td>
</tr>
<tr>
<td>Oil content (%)</td>
<td>0.28</td>
<td>4.70**</td>
<td>15.45**</td>
<td>1.18**</td>
<td>0.85</td>
<td>4.91**</td>
<td>2.66**</td>
<td>0.37</td>
</tr>
<tr>
<td>Seed yield per plant (g)</td>
<td>1.59</td>
<td>1.73**</td>
<td>6.79**</td>
<td>3.70**</td>
<td>0.002</td>
<td>1.79**</td>
<td>1.55</td>
<td>0.53</td>
</tr>
</tbody>
</table>

*, ** significant at 5 and 1 per cent probability levels, respectively.

Table 2: Prospective cross combinations based on desirable SCA effects for seed yield and oil content in Indian mustard

<table>
<thead>
<tr>
<th>Characters</th>
<th>Cross combinations</th>
<th>SCA effects</th>
<th>Heterosis (%)</th>
<th>Other characters with significant sCA effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed yield per plant (g)</td>
<td>CMSMori x NPJ-135</td>
<td>1.55**</td>
<td>13.17*</td>
<td>12.83*</td>
</tr>
<tr>
<td>CMSNDRE-4 x PRE-2007-06</td>
<td>1.52**</td>
<td>11.75*</td>
<td>11.41</td>
<td>PH, NSR, TW, BY, OC, SY</td>
</tr>
<tr>
<td>CMSMori x NPJ-147</td>
<td>1.31*</td>
<td>7.70</td>
<td>7.37</td>
<td>NSR, TW, BY, SY</td>
</tr>
<tr>
<td>CMSNDRE-4 x DRMREJ-2010-01</td>
<td>1.27*</td>
<td>2.03</td>
<td>1.72</td>
<td>D50%F, NSR, BY, SY</td>
</tr>
<tr>
<td>CMSNDRE-4 x PRE-2007-06</td>
<td>0.97**</td>
<td>3.44**</td>
<td>7.86**</td>
<td>PH, NSR, TW, BY, OC, SY</td>
</tr>
<tr>
<td>CMSMori x NDRE-08-04</td>
<td>0.89**</td>
<td>1.11</td>
<td>5.43**</td>
<td>NSR, NSS, BY, OC</td>
</tr>
<tr>
<td>CMSMori x NDRE-07</td>
<td>0.77**</td>
<td>1.65</td>
<td>5.99**</td>
<td>NSR, TW, OC</td>
</tr>
<tr>
<td>CMSNDRE-4 x DRMREJ-2010-02</td>
<td>0.73**</td>
<td>5.52**</td>
<td>10.03*</td>
<td>OC</td>
</tr>
</tbody>
</table>
Two crosses viz., CMSMori x NPJ-135 and CMSNDRE-4 x PRE-2007-06 were reported good specific combiners as well as high heterotic over both the standard varieties i.e., Kranti (SV1) and Maya (SV2). This indicated the existence of positive association between SCA effects and heterotic response. However, the crosses exhibiting significant SV1 heterosis for oil content in desirable direction were CMSNDRE-4 x PRE-2007-06. And cross CMSMori x NPJ-135 over SV2 exhibited significant positive heterosis for oil content. Manifestation of considerable heterosis for such yield components is finding earlier by Goswami et al. (2004), Shanti Patil et al. (2005) and Singh et al. (2007).

To exploitation of heterosis through cytoplasmic male sterility to find out best hybrids viz., CMSMori x NPJ-135 and CMSNDRE-4 x PRE-2007-06 over SV2, as well as SV2, emerged as outstanding crosses for seed yield.

A perusal of Table II and III, revealed that heterosis in seed yield was proportional to the heterosis observed for yield components. In majority of cases heterosis in most of the components registered heterosis for seed yield. The two crosses showing significant heterosis for seed yield were also found to register significant positive standard heterosis over SV2 for plant height, number of primary branches per plant, number of secondary branches per plant, 1000-seed weight, biological yield and oil content. However, one cross, which showed positive heterosis over SV2 for seed yield, has also having positive and significant standard heterosis for characters viz., plant height, number of secondary branches per plant, number of silique on main raceme and oil content.

Obviously, plant height, number of primary branches per plant, number of secondary branches per plant, number of silique on main raceme, 1000-seed weight, biological yield and oil content, as most important components associated with manifestation of heterosis for seed yield. This confirms the view that heterosis for seed yield is reflected through superiority of yield components. These observations corroborate with the findings of Goswami et al. (2004), Yadav et al. (2004), Shanti Patil et al. (2005) and Singh et al. (2007) who also find that secondary branches per plant, plant height, silique on main raceme, primary branches per plant and seeds per silique as the important components in determining heterosis for seed yield in Indian mustard. Besides yield, considerable heterosis has been observed for other characters also, but its degree considerably depends upon the characters.

From the foregoing research, it has become evident that majority of heterotic crosses for seed yield and its attributes involved either one or both the good/ average GCA parents. Therefore, they can exploit further for yield improvement. Further, average x high were found predominantly cross combinations, which are responsible for high heterosis seed yield whereas, the cross average x average were also reported high heterosis response for seed yield. This combination depicted the importance of additive x dominance gene interaction.

The outstanding crosses may be usefully exploited commercially in the production of hybrids. Therefore, for the commercial exploitation of hybrids vigour in mustard, still further studies are required to identify perfect restorers for different CMS lines. At present, several cytoplasmic male sterility systems have been developed at exploitable level for hybrids seed production. However, fertility restoration have very serious problem in all CMS system, which require further improvement in regards to their commercial exploitation.

### REFERENCES


