Gynoecy in bitter melon (Momordica charantia) for exploiting hybrid vigour

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Abstract
Development of hybrids in bitter melon is expensive because of hand pollination but the utilisation of gynoecy is economical and easier for exploiting hybrid vigour in bitter melon. A study was conducted to determine magnitude of heterosis in bitter melon by making crosses on one gynoecious line, DBGY-201 with eight other inbreds. It was observed that all the hybrids showed significant heterosis in desirable directions for traits like sex ratio, days to first picking, fruit weight, length and girth, yield per plant and vine length. The gynoecious hybrid DBGY-201 × ‘Pusa Vishesh’ showed highest heterosis (-19 %) for earliness and the hybrid DBGY-201 × ‘Priya’ was reported to provide maximum heterosis for fruit length, weight and yield. These gynoecious hybrids have immense potentiality for future breeding programme in bitter melon improvement.

INTRODUCTION
Sex determination is a process that leads to the physical separation of male and female gamete-producing structures to different individuals of a species. A wide range of variation in sex forms ranging from hermaphrodite to monoecious forms is observed in cucurbitaceous vegetable crops (Robinson and Decker-Walters 1999). Among these the gynoecious sex (only female flowers) form has been commercially exploited worldwide for cucumber breeding programme. Dogra et al. (1997) reported high better and standard parent heterosis in cucumber when a gynoecious line is used as female parent. More (2002) also demonstrated potentiality in cucumber for development of tropical gynoecious hybrids. The predominant sex form in bitter melon (Momordica charantia L) is monoecious (Behera 2004), however, gynoecious sex form has been reported by Ram et al. (2002), Behera et al. (2006) from India and Zhou et al. (1998) from China. The subsequent generations using gynoecious as one parent shows very high percentage of pistillate flowers and have high yield potential (Behera et al. 2006). Development of hybrids in any crop is expensive. However, the utilisation of gynoecy is economical and easier (Behera 2004) for exploiting hybrid vigour in many cucurbitaceous crops including bitter melon that have high male:female sex ratio and require hand pollination. This study determined the extent of heterosis in the hybrids by using gynoecious line as one of the parents.
MATERIALS AND METHODS

Eight genetically diverse inbred lines/cultivars of bitter melon namely, ‘Pusa Do Mausami’, ‘Pusa Vishesh’, PBIG-44-3, NDBT-12, ‘Priya’, DVBTG-5-5, ‘Nakhara’ and ‘Arka Harit’ were crossed with DBGY-201 (gynoecious line) to estimate heterosis in 2006. During spring-summer (February to May) season of 2007, these 8 hybrids along with the 9 parental inbreds were grown at Experimental Farm, Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi, India. The experiment was laid out in randomised block design with 3 replications of x plants per genotype. The data were recorded for sex ratio (male: female), days to first picking, fruit weight, length and girth, fruit number and yield per plant, and vine length. The data on per se performance of individual hybrid are presented in Table 1. The mid heterosis (%) was calculated over mean value of both the parents using the following formula:

\[
\text{Mid parent heterosis} = 100 \times \frac{(F_1 - MP)}{MP}
\]

where \(F_1\) = mean performance of the hybrid and \(MP\) = mean value of both parents

The data were analysed in the SPAR 1 software of Indian Agricultural Statistical Research Institute, New Delhi, India.

RESULTS AND DISCUSSION

The results of the present study revealed significant heterosis over standard check (‘Pusa Do Mausami’) for all traits (Tab. 1). The range of mid parent heterosis for sex ratio (male versus female) varied from -58 to -99 per cent and hybrid DBGY-201 × ‘Arka Harit’ showed maximum heterosis in negative direction with sex ratio of 0.07 (Tab. 1). Some hybrids exhibited significant negative heterosis for days to first picking as compared to check ‘Pusa Do Mausami’ and the heterosis in desirable direction was highest (-19.40 %) in DBGY-201 × ‘Pusa Vishesh’. This hybrid took a minimum period of ~47 days to first picking from the date of sowing (~72 days for ‘Pusa Do Mausami’). The fruit characteristics were also considerably better in almost all the gynoecious hybrids; among them three showed significant positive heterosis for fruit weight. Maximum fruit weight (104 g) was observed in hybrid DBGY-201 × ‘Priya’. However, for fruit length two hybrids (DBGY-201 × ‘Priya’; and DBGY-201 × ‘Pusa Vishesh’) showed positive heterosis. Two hybrids showed significant positive heterosis for fruit girth and the hybrid DBGY-201 × “Priya” exhibited maximum fruit girth (4.6 cm).

All hybrids also gave a greater number of fruits than the standard parent and the best combination was DBGY-201 × DVBTG-5-5 (142 %) followed by DBGY-201 × ‘Priya’ (132 %), DBGY-201 × NDBT-12 and DBGY-201 × “Pusa Do Mausami” (108 %). In cucumber, Fan et al. (2006) identified a positive correlation \((r^2 = 0.40)\) between gynoecy and fruit number which suggested the association between yield and sex expression. Yield per plant was significantly higher in all the hybrids and yield was more than double than the standard parent in three hybrids. The best combinations were DBGY-201 × ‘Priya’ (104 % heterosis; Tab. 1) followed by DBGY-201 × ‘Arka Harit’ (102 %), and DBGY-201 × NDBT-12 (98 %). Shorter vine length is preferred in all the cucurbits by virtue of their greater fruitfulness. Significant negative heterosis was exhibited by all the hybrids. Highest negative heterosis (-16 %; Tab. 1) was shown by DBGY-201 × ‘Pusa Do Mausami’ followed
by DBGY-201 × PBIG-44-3 (-6 %) and the shortest vine length was reported in
DBGY-201 × ‘Pusa Vishesh’ (188 cm).

Table 1. Heterosis over the mid parent (first line) and value (second line) for several
tergonomical traits of F1 hybrids between the gynoecious parent (DBGY-201) and
several monoecious lines compared with the standard check ‘Pusa Do Mausami’.

<table>
<thead>
<tr>
<th>Crosses</th>
<th>Sex ratio (M:F)</th>
<th>Days to 1st picking</th>
<th>Fruit weight</th>
<th>Fruit length</th>
<th>Fruit girth</th>
<th>Fruits per plant</th>
<th>Yield per plant</th>
<th>Vine length</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBGY-201 ×</td>
<td>-68.1</td>
<td>-17.9</td>
<td>9.9</td>
<td>-0.4</td>
<td>0.87</td>
<td>108.0</td>
<td>89.4</td>
<td>-15.9</td>
</tr>
<tr>
<td>‘Pusa Do Mausami’</td>
<td>2.8**</td>
<td>48.8**</td>
<td>92.8**</td>
<td>10.9</td>
<td>4.07</td>
<td>38.9**</td>
<td>3.6**</td>
<td>213.1</td>
</tr>
<tr>
<td>DBGY-201 ×</td>
<td>-69.0</td>
<td>-19.4</td>
<td>2.7</td>
<td>13.9</td>
<td>-3.90</td>
<td>87.4</td>
<td>81.6</td>
<td>-4.2</td>
</tr>
<tr>
<td>‘Pusa Vishesh’</td>
<td>2.3**</td>
<td>47.6**</td>
<td>88.4**</td>
<td>12.6**</td>
<td>3.94</td>
<td>34.7**</td>
<td>3.1**</td>
<td>187.8**</td>
</tr>
<tr>
<td>DBGY-201 ×</td>
<td>-92.4</td>
<td>-1.6</td>
<td>-11.6</td>
<td>0.6</td>
<td>4.09</td>
<td>48.2</td>
<td>65.4</td>
<td>-6.0</td>
</tr>
<tr>
<td>PBIG-44-3</td>
<td>1.1**</td>
<td>64.2</td>
<td>78.6</td>
<td>10.8</td>
<td>4.07</td>
<td>29.1**</td>
<td>2.3**</td>
<td>253.8</td>
</tr>
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<td>DBGY-201 ×</td>
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<td>-4.2</td>
<td>8.1</td>
<td>20.4</td>
<td>5.74</td>
<td>108.4</td>
<td>97.9</td>
<td>-1.8</td>
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<td>53.8**</td>
<td>76.1</td>
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<td>3.87</td>
<td>38.3**</td>
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<td>225.3</td>
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<tr>
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<td>4.6</td>
<td>10.7</td>
<td>4.8</td>
<td>5.88</td>
<td>131.9</td>
<td>104.0</td>
<td>-5.52</td>
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<td>‘Priya’</td>
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<td>68.2</td>
<td>103.9**</td>
<td>14.2”</td>
<td>4.59”</td>
<td>35.0**</td>
<td>3.6**</td>
<td>258.9</td>
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<tr>
<td>DBGY-201 ×</td>
<td>-58.0</td>
<td>33.3</td>
<td>26.8</td>
<td>8.1</td>
<td>14.20</td>
<td>142.2</td>
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<td>-4.8</td>
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<td>DVBTG-5-5</td>
<td>5.1**</td>
<td>79.5</td>
<td>83.9</td>
<td>10.4</td>
<td>3.90</td>
<td>42.9**</td>
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<td>-7.2</td>
<td>-3.1</td>
<td>2.8</td>
<td>3.85</td>
<td>55.9</td>
<td>90.0</td>
<td>-1.5</td>
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<td>‘Nakhara’</td>
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<td>54.8**</td>
<td>67.0</td>
<td>10.3</td>
<td>3.90</td>
<td>32.0**</td>
<td>2.2**</td>
<td>209.7</td>
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<td>-99.3</td>
<td>-16.9</td>
<td>-2.4</td>
<td>12.4</td>
<td>9.34</td>
<td>97.1</td>
<td>101.7</td>
<td>-0.9</td>
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<td>81.5</td>
<td>10.7</td>
<td>5.27”</td>
<td>35.8”</td>
<td>2.9**</td>
<td>232.9</td>
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<td>‘Pusa Do Mausami’</td>
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<td>71.8</td>
<td>83.0</td>
<td>12.0</td>
<td>3.84</td>
<td>19.4</td>
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<td>LSD (at 5 %)</td>
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<td>8.46</td>
<td>5.38</td>
<td>1.15</td>
<td>0.40</td>
<td>2.81</td>
<td>0.24</td>
<td>17.87</td>
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<tr>
<td>LSD (at 1 %)</td>
<td>5.16</td>
<td>11.25</td>
<td>7.15</td>
<td>1.54</td>
<td>0.53</td>
<td>3.75</td>
<td>0.32</td>
<td>23.77</td>
</tr>
</tbody>
</table>

* and ** = Significantly different from ‘Pusa Do Mausami’ at the 5 % and 1 % level, respectively.

From the above results it became clear that crosses involving gynoecious line
as the female parent outperformed for most of the characters under study. Lawande
and Patil (1989) reported higher standard heterosis for yield per vine (86 %), number
of fruits per vine (63 %), and fruit weight (22 %) in monoecious bitter gourd hybrids.
Thus gynoecious line, DBGY-201 holds immense potentiality for future breeding
programme in bitter melon improvement. The most noticeable effect of sex
expression on cucumber yield was observed by using gynoecious × gynoecious and
gynoecious × monoecious hybrids that produced significantly higher yield (Wehner
and Miller 1984). The gynoecious hybrids in bitter gourd may be suitable for
mechanical harvesting because of their early, concentrated fruit set during first
picking as it was previously demonstrated in cucumber (Lower and Edwards 1986;
Staub and Bacher 1997).
Literature cited