Heterosis and Combining Ability for Polygenic Traits in Late Maturity Hybrids of Maize, Zea mays (L.)

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Combining ability analysis was conducted using line x tester design in late maturity inbred lines of maize (Zea mays L.) for yield and yield contributing traits. Three lines viz., KML-2, KML-30 and KML-181 were good general combiners for grain yield. Among the hybrids, KML-225 x KML-226 recorded high per se performance for grain yield followed by KML-2 x KML-226. The hybrid, KML-227 x KML-161 was found to be superior in terms of days to 75 per cent dry husk and KML-181 x KML-75 for ear length, ear girth, number of ears per plant and number of kernel rows. These crosses showed significant heterosis for yield contributing characters. The estimates of general combining ability and specific combining ability revealed the presence of non-additive gene action for all the traits under study.

Key words: Maize, heterosis, combining ability, gene action, line x tester analysis

In India, maize is the third most important cereal after rice and wheat that provides food, feed, fodder, and serves as a source of raw material for developing hundreds of industrial products viz., starch, protein, oil, alcoholic beverages, food sweeteners, pharma, cosmetics, bio-fuel, etc. In 2009-10, Maize was cultivated in India in an area of 8.17 million hectare with a production of 19.73 million tonnes and productivity of 2.4 tonnes per hectare. The traits like yield and its components are governed by polygenes with complex gene action and hence understanding the nature and magnitude of gene action helps the breeder in selection of an appropriate breeding method (Hallauer and Miranda, 1981). In Zea mays, the importance of additive as well as non additive gene effects has been earlier reported by Dubey et al. (2001), Joshi et al. (2002), Srivastava and Singh (2003) and Lata et al. (2008). For improvement in such an important crop, the most important prerequisite is the selection of suitable parents, which could combine well and produce desirable hybrids. In the present study, an attempt has been made to estimate the heterosis in F1 hybrids with respect to yield, the combining ability and gene action governing the quantitative traits in maize, using line x tester mating design.

Materials and Methods

Eighteen diverse late maturity genotypes of maize were studied in this experiment. Eighteen genotypes consisted of ten lines namely, KML-2, KML-4, KML-5, KML-8, KML-10, KML-30, KML-125, KML-181, KML-225 and KML-227 and eight testers namely, KML-3, KML-35, KML-36, KML-55, KML-58, KML-75, KML-161 and KML-226. These parents were crossed in a line x tester mating design in rabi, 2008 and resultant eighty crosses along with recently released university hybrid DHM-117 as standard check were raised in RBD with three replications during kharif, 2009-10 at Agricultural Research Station, Karimnagar. Heterosis was assessed over the standard check (standard heterosis). The data on twelve quantitative characters namely, plant height, ear height, ear length, ear girth, number of kernel rows and number of kernels per row were recorded on five randomly selected competitive plants in each replication, whereas days to 50 per cent pollen shedding, days to 50 per cent silk emergence, days to 75 per cent dry husk, number of ears per plant, grain yield (q/ha) and 100 kernels weight were recorded on plot basis. To know the barrenness, an undesirable trait number of ears per plant were recorded on plot basis (Ear count/Plant count). Line x Tester analysis without parents was carried out as per the method suggested by Kempthorne (1957). Heterosis was estimated over the check as per the standard procedure.

Results and Discussion

The analysis of variance for all the yield and yield component traits showed that, variance due to hybrids was highly significant for all the traits studied indicating the manifestation of parental genetic variability in their crosses. The mean squares for hybrids were partitioned into three components viz., due to lines, due to testers and due to line x tester interactions. The differences among hybrids due to the lines, testers and line x tester interaction were
significant for all the characters except number of ears per plant in testers there by suggesting that the experimental material possessed considerable variability and that both gca and sca were involved in genetic expression of these traits. The non-significance of variance for number of ears/plant in testers suggests that the testers had comparable genetic expression of these traits. The non-

gaca variance was good general combiner for ear height, ear length, ear girth and 100 kernels weight; KML-226 for days to 75 per cent dry husk, plant height, ear height, number of kernel rows and 100 kernels weight.

Among testers, KML-3, KML-35, KML-36 and KML-225 x KML-226 were good specific combiners for grain yield. The tester KML-3 was good general combiner for ear height, ear length, ear girth and 100 kernels weight; KML-35 for plant height, ear girth, number of kernel rows and 100 kernels weight; KML-36 for ear height and KML-225 for days to 75 per cent dry husk, plant height, ear girth, number of kernel rows and 100 kernels weight.

Among hybrids, KML-225 x KML-226 was the best specific combiner for grain yield followed by KML-125 x KML-35, KML-181 x KML-75 and KML-181 x KML-35, KML-181 x KML-75 and KML-10 x KML-225.
227 x KML-161 (Table 3). The cross KML-227 x KML-161 was desirable for early maturity with significant 
sc, heterosis and low mean values for number of
days to 75 per cent dry husk. The cross KML-225 x
KML-226 was desirable for high grain yield with
significant sc, heterosis and high mean values for
100 kernel weight. The cross KML-181 x KML-75
had positive and highly significant sc, effect for all
the yield and yield contributing characters namely
ear length, ear girth, number of ears per plant,
number of kernel rows, number of kernels per row,
100 kernels weight. These results are in similarity
with the earlier findings of Srivastava and Singh
(2003) and Jyoti et al. (2006).

In the estimation of heterosis, Sharma (1994)
opined that heterosis over the best check or the
local variety could be considered as the better criteria
for evaluation of hybrids. The present study revealed

that the distribution of heterosis in both positive and
negative directions for all the traits.

The hybrids viz., KML-227 x KML-161 and KML-
225 x KML-75 recorded significant standard negative
heterosis for days to 75 per cent dry husk, combined
with significant negative sc, and low mean
performance. Hence, these hybrids could be utilized
to develop the hybrids with medium maturity.

For ear length, hybrids KML-225 x KML-3 and
KML-181 x KML-75 recorded significant
sc, heterosis and good 
sc, performance but failed to express heterosis.
The cross KML-181 x KML-75 recorded
significant s, heterosis and high mean values for
ear length, number of ears per plant and significant

Table 3. Specific combining ability, standard heterosis and per se performance of best performing crosses

<table>
<thead>
<tr>
<th>Character</th>
<th>KML-225 x KML-226</th>
<th>KML-125 x KML-35</th>
<th>KML-181 x KML-75</th>
<th>KML-227 x KML-161</th>
<th>KML-9 x KML-161</th>
<th>KML-227 x KML-35</th>
<th>KML-4 x KML-35</th>
<th>SE (m) ±</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>het. 13.50**</td>
<td>-0.33</td>
<td>-5.30</td>
<td>-6.43</td>
<td>-13.62**</td>
<td>1.13</td>
<td>3.90</td>
<td>4.28</td>
</tr>
<tr>
<td></td>
<td>per se 88.36</td>
<td>77.60</td>
<td>73.73</td>
<td>72.85</td>
<td>67.25</td>
<td>78.73</td>
<td>80.89</td>
<td></td>
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<tr>
<td>Days to 50 per cent</td>
<td>sca 0.821</td>
<td>0.712</td>
<td>0.546</td>
<td>-0.929</td>
<td>-1.346</td>
<td>1.471**</td>
<td>0.546</td>
<td>0.726</td>
</tr>
<tr>
<td></td>
<td></td>
<td>per se 53.00</td>
<td>54.33</td>
<td>52.00</td>
<td>52.00</td>
<td>52.33</td>
<td>56.33</td>
<td>52.00</td>
</tr>
<tr>
<td>Days to 50 per cent</td>
<td>sca -0.329</td>
<td>0.979</td>
<td>2.713**</td>
<td>-1.887**</td>
<td>0.404</td>
<td>0.946</td>
<td>0.688</td>
<td>0.784</td>
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<tr>
<td></td>
<td>silk emergence</td>
<td>het. -7.34**</td>
<td>-2.82*</td>
<td>-8.47**</td>
<td>-6.35**</td>
<td>-1.13</td>
<td>-6.78**</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>per se 54.67</td>
<td>57.33</td>
<td>57.33</td>
<td>54.00</td>
<td>56.67</td>
<td>58.33</td>
<td>55.00</td>
</tr>
<tr>
<td>Days to 75 per cent</td>
<td>sca 2.613**</td>
<td>-1.512*</td>
<td>1.146</td>
<td>-3.071**</td>
<td>0.512</td>
<td>-0.971</td>
<td>0.362</td>
<td>0.729</td>
</tr>
<tr>
<td></td>
<td>dry husk</td>
<td>het. -2.24</td>
<td>-2.24</td>
<td>-2.24</td>
<td>-8.96**</td>
<td>-5.60**</td>
<td>-2.99**</td>
<td>-1.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>per se 87.33</td>
<td>87.33</td>
<td>87.33</td>
<td>81.33</td>
<td>84.33</td>
<td>86.67</td>
<td>87.67</td>
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<td></td>
<td></td>
<td>pollen shedding</td>
<td>het. 5.05</td>
<td>5.75</td>
<td>2.61</td>
<td>2.44</td>
<td>0.17</td>
<td>-2.79</td>
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<td></td>
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<td></td>
<td>per se 201.00</td>
<td>180.33</td>
<td>186.33</td>
<td>196.00</td>
<td>191.67</td>
<td>161.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-0.63</td>
<td>-7.30</td>
<td>-2.54</td>
<td>10.48</td>
<td>-1.90</td>
<td>24.44**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>per se 104.33</td>
<td>97.33</td>
<td>102.33</td>
<td>110.00</td>
<td>122.33</td>
<td>108.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ear length</td>
<td>sca 0.059</td>
<td>0.685</td>
<td>2.511**</td>
<td>0.452</td>
<td>0.352</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.97</td>
<td>16.02**</td>
<td>1.94*</td>
<td>-3.40**</td>
<td>5.34**</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>per se 16.83</td>
<td>17.00</td>
<td>19.92</td>
<td>17.50</td>
<td>16.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ear girth</td>
<td>sca 0.183</td>
<td>-1.148**</td>
<td>1.395**</td>
<td>0.692**</td>
<td>0.403</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>-0.97</td>
<td>16.02**</td>
<td>1.94*</td>
<td>-3.40**</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>per se 18.00</td>
<td>15.13</td>
<td>13.25</td>
<td>15.67</td>
<td>14.08</td>
</tr>
<tr>
<td>No. of ears/plant</td>
<td>sca 0.056</td>
<td>0.055</td>
<td>0.097*</td>
<td>0.026</td>
<td>0.034</td>
<td>0.063</td>
<td>0.072</td>
<td>0.04</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>per se 5.31**</td>
<td>9.21**</td>
<td>15.43**</td>
<td>7.72**</td>
<td>7.02**</td>
</tr>
<tr>
<td>No. of kernel rows</td>
<td>sca -1.067*</td>
<td>-0.929*</td>
<td>1.496**</td>
<td>0.429</td>
<td>0.512</td>
<td>-0.038</td>
<td>0.779</td>
<td>0.438</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td>per se -13.04**</td>
<td>4.35**</td>
<td>-4.35**</td>
<td>-4.35**</td>
<td>-6.22**</td>
</tr>
<tr>
<td>No. of kernels/row</td>
<td>sca 0.079</td>
<td>4.421**</td>
<td>4.496**</td>
<td>1.004</td>
<td>3.962**</td>
<td>-2.729**</td>
<td>1.796</td>
<td>0.951</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>per se -6.16**</td>
<td>10.20**</td>
<td>5.10**</td>
<td>7.65**</td>
<td>9.69**</td>
</tr>
<tr>
<td>100 kernel weight</td>
<td>sca 6.467**</td>
<td>1.486*</td>
<td>2.897**</td>
<td>2.000</td>
<td>-0.525</td>
<td>0.510</td>
<td>2.734**</td>
<td>0.704</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>per se 22.13**</td>
<td>-9.52**</td>
<td>-0.34</td>
<td>-16.17**</td>
<td>-3.78**</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>per se 35.50</td>
<td>36.00</td>
<td>28.97</td>
<td>24.37</td>
<td>23.00</td>
</tr>
</tbody>
</table>

*Significant at P<0.05; **Significant at P<0.01
sca and heterosis for number of kernel rows and number of kernels per row.

For 100 kernels weight, the crosses KML-225 x KML-226 and KML-30 x KML-3 recorded significant heterosis coupled with good mean performance and high sca effect.

Based on per se performance, the next best crosses observed for grain yield were KML-2 x KML-226, KML-4 x KML-35 and KML-181 x KML-36. These results are in similarity with the earlier findings of Srivastava and Singh (2003) and Jyoti et al. (2006). The lines KML-2, KML-30 and KML-181 and the testers KML-3, KML-35, KML-36 and KML-226 had significant gca effect for grain yield and its contributing characters and thus could be used as parents for the development of high yielding single crosses hybrids. The high yielding hybrids KML-225 x KML-226, KML-2 x KML-226 and KML-227 x KML-161 with early maturity could be used for its performance over the locations. The hybrids KML-125 x KML-35 and KML-181 x KML-75 showed high sca effect, per se performance for grain yield and were identified for further multilocation evaluation.

References


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