EVALUATION OF MAIZE HALF SIB FAMILIES FOR MATURITY AND GRAIN YIELD ATTRIBUTES

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ABSTRACT

This study was undertaken at the Research Farm of KP Agricultural University, Peshawar during 2008 to evaluate half-sib maize families for maturity, yield and yield related traits. One hundred and forty four half-sib families derived from maize variety Pahari were used in the study. The experiment was laid out in 12X12 partial balance lattice design with two replications. Results indicated that the half-sib families were significantly different from one another for all the traits studied. Among the 144 families, maximum anthesis-silking interval (3.5) was recorded for HS-74. On the other hand minimum anthesis silking interval (2) was recorded for HS-53. Maximum plant height (192.5 cm) was observed for HS-67 while minimum (140 cm) was recorded for HS- 101. Minimum ear height (48 cm) was observed for HS-98 while maximum (97.5 cm) was recorded for HS-78. HS-2 exhibited the maximum ear length (18.5) whereas HS-77, HS-20 and HS-32 showed the minimum ear length (12 cm). Highest kernel rows ear-1 (16) was observed for HS-12 and HS-113 whereas minimum (11) was recorded for HS-9, HS-72, HS-102 and HS-138. Maximum 100 grains weight (33.6 g) was exhibited by HS-93 while minimum (20 g) was exhibited by HS-84. Highest (6987 kg) grain yield was recorded for HS-51 while minimum (2269 kg) was showed by HS-102. Maximum heritability estimate (0.88) was observed for days to mid silking, while minimum (0.46) was observed for kernel rows cob1. Maximum correlation of yield was recorded with plant height and ear length. These results suggest that these half-sib families could be used as source of improved maize germplasm for developing maize genotypes with superior attributes.

Key Words: Zea mays L, half-sib families, yield attributes, correlations

INTRODUCTION

Maize (Zea mays L.) is one of the most important cereal crops of the world grown in the irrigated and rainfed areas. It is a cross pollinated, annual and short day crop that can be grown in tropical and sub tropical regions with high temperature and enough sunshine. It can be grown on all types of soils ranging from sandy to clay; however, medium textured soil of pH 6.5 to 7.5 is more suitable for maize. Maize plant is protandrous in which pollen shedding normally begins 1-3 days before the silks have emerged from the husks of the same plant and usually continues for a period of several days after the silks are ready to be pollinated. Hot dry weather tends to hasten the pollen shedding (Poehlman, 1977).

Maize is a multipurpose crop used for food, feed, fodder and several industrial products. About two third of the total world production of maize is used for livestock feed or for commercial starch and oil production. It has a great nutritional value as it contains about 66.7% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 7% ash (Chaudhry, 1983).

In Pakistan during the year 2006-07, maize was grown on 1016.9 thousand hectares, with the total annual production of 3088.4 thousands tones and an average yield of 3037 kg hectare$^{-1}$ (MINFAL, 2006-07). The major limiting factors for the low yield per unit area include unavailability of suitable and inexpensive maize hybrid seed, associated with price of hybrid seed, thus forcing the farmers to plant open pollinated varieties.

Several methods of selection such as mass selection, modified ear to row selection, recurrent selection, full sib and half sib family recurrent selection methods have been used by maize breeders for improving yield per unit area and developing high yielding maize varieties. Recurrent selection programs involving S$_1$ progeny selection and half-sib family selection are of particular interest in this regard as these not only improve the breeding populations for the desired attributes but maintain the genetic variability in the population as well (Eberhart et al. 1973; Beavis et al. 1994). Coors (1988) observed a gain of 3.5% in grain yield and 1.5% reduction in grain moisture per cycle in response to four cycles of combined half-sib and S1 family selection in
maize. Tanner and Smith (1987) suggested that half-sib family selection was highly effective in reducing inbreeding depression in maize populations.

The objectives of this study were to evaluate half-sib families derived from maize variety Pahari to identify superior half-sib maize families that can be used in future maize breeding programs for developing maize genotypes with desirable attributes. Estimates of heritability and correlation among yield and yield related traits were other parameters of interest in these half sib families.

MATERIALS AND METHODS

The experiment was conducted at the Research Farm of KP, Agricultural University, Peshawar, Pakistan during summer crop season 2008. Experimental material comprised 144 half-sib families, derived from maize variety Pahari which was very kindly provided by the maize breeding group at Cereal Crop Research Institute (CCRI), Pirsabak (Nowshera). Half sib families have one parent in common and were produced in isolation during the spring crop season (February-June) of the same year (2008) at CCRI, Pirsabak by planting the male and female rows in a ratio 1:2. The experiment was laid out in Partial lattice square design with two replications. Plant to plant and row to row distance was 25 cm and 75 cm, respectively. Two seeds hill⁻¹ were sown and latter thinned to one seedling hill⁻¹ at knee height stage. All agronomic practices were carried out at appropriate time as and when needed. Data on morphological and yield parameters were recorded during the course of the experiment, appropriate for each parameter.

Silking data were recorded on plant basis as the number of days from sowing until 50% of plants in the plot showed silks while days to anthesis were worked out by visual observation when 50% of the plants in the plot started shedding pollen. The days were counted from the date of sowing. Anthesis silking interval (ASI) was calculated on plot basis as the difference between silking and anthesis. Plant height was measured as distance in cm from ground level to the upper most node of the plant on three randomly selected plants plot⁻¹, whereas ear height measurements were taken as the average distance in cm from ground level to the node bearing uppermost ear on three randomly selected plants plot⁻¹. Ear length was measured from the base to the tip of the ear with scale in cm on a similar sample of three ears, whereas kernel rows per ear were counted on three randomly selected ears after harvest. The moisture contents of the grains were taken using grain moisture tester, after shelling the middle rows from three randomly selected ears at the time of harvest. Hundred grains were counted randomly from the grain lot of each plot and weighed with the help of electronic balance. Grain yield per hectare was calculated from the data of fresh ear weight plot⁻¹ and adjusted to 15% grain moisture level.

Statistical Analysis

The data were subjected to ANOVA appropriate for Lattice Square Design, using computer program ‘MSTAT-C’. Means of all parameters were also calculated for relative comparison among the half sib families. Variance components and heritability estimates were computed following Fehr (1987).

RESULTS AND DISCUSSION

Flowering Traits

Highly significant differences (P<0.01) were observed among the half sib families for all the flowering traits including days to mid anthesis and mid silking. Low coefficient of variation (CV) was observed for days to mid pollen shedding (2.47) and mid silking (2.28). Anthesis-silking interval calculated from the difference of mid anthesis and mid silking, also showed highly significant (P<0.01) differences among the half sib families (Table I). These results are in agreement with those of Hidayatullah et al., (2006) who also observed highly significant differences for mid-tasseling, mid anthesis and mid silking while evaluating the performance of local and exotic inbred lines of maize under agro-ecological conditions of Peshawar, Coors (1988) reported that four cycles of combined half sib and S1 family selection resulted 3.5% increase in grain yield and grain moisture reduction by 1.5% per cycle in maize synthetic.

HS-86, HS-93 and HS-109 took maximum days (51) to mid anthesis, while minimum days (42) were recorded for HS-6. Heritability estimates of 0.77 were observed for this trait (Table I), which indicates low environmental effect and the relative improvement potential of this trait in this breeding material. HS-74 and HS-109 took maximum days (53) to silking, while minimum days (42) were recorded for HS-6 (Table II). Heritability estimate for days to mid silking was 0.88 (Table I). Days to mid silking was positively correlated with all the traits studied except 100 grain weight (Table III). In contrast to our results, Eleweanya et al. (2005) reported a negative correlation between days to mid silking and grain yield which might be due to differences in germplasm studied. Plant breeders are interested in pollen-silk synchronization i.e. low ASI is preferred because large gap between pollination and silking could lead to low kernel setting and hence reduced grain yield. Minimum anthesis silking interval (2) was calculated for HS-53 (protogynous), while maximum (3.5) was
observed for HS-74 (protandrous) - Table II. Moderate heritability of 0.58 was observed for anthesis silking interval. This reflects considerable influence of the environmental factors on this maturity parameter like polygenically controlled grain yield traits.

**Plant and Ear Height**

Plant and ear height play an important role in plant lodging. Therefore, maize breeders give special attention to these two traits in maize breeding. Low plant height and central or near to central placement of the top ear on the plant is desired, because such plants are less vulnerable to lodging and hence could contribute to enhanced grain yield. Analysis of variance regarding plant and ear height revealed highly significant (P<0.01) differences among the half sib families for these two traits. Stromberg and Campton (1989) also reported significant differences regarding plant and ear height after 10 cycles of full-sib recurrent selection in Nebraska Krung open pollinated maize. Coefficient of variation (CV) for plant and ear height was 7.17 and 13.39 %, respectively (Table I) and were therefore in the acceptable range as commonly observed in field experiments.

<table>
<thead>
<tr>
<th>Plant Trait</th>
<th>Replication</th>
<th>Families</th>
<th>Blocks</th>
<th>Error</th>
<th>CV (%)</th>
<th>( h^2 ) (BS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to anthesis</td>
<td>34.72</td>
<td>5.34**</td>
<td>12.76</td>
<td>1.38</td>
<td>02.47</td>
<td>0.77</td>
</tr>
<tr>
<td>Days to silking</td>
<td>42.01</td>
<td>9.94**</td>
<td>24.44</td>
<td>1.22</td>
<td>02.28</td>
<td>0.88</td>
</tr>
<tr>
<td>Anthesis silking interval</td>
<td>0.35</td>
<td>2.373**</td>
<td>4.82</td>
<td>1.25</td>
<td>19.70</td>
<td>0.58</td>
</tr>
<tr>
<td>Plant height</td>
<td>238.35</td>
<td>265.33**</td>
<td>214.92</td>
<td>139.03</td>
<td>07.17</td>
<td>0.58</td>
</tr>
<tr>
<td>Ear height</td>
<td>208.42</td>
<td>198.64**</td>
<td>121.28</td>
<td>92.92</td>
<td>13.39</td>
<td>0.62</td>
</tr>
<tr>
<td>Ear length</td>
<td>95.65</td>
<td>3.091**</td>
<td>4.54</td>
<td>2.06</td>
<td>09.73</td>
<td>0.50</td>
</tr>
<tr>
<td>Kernel rows cob(^{-1})</td>
<td>2.35</td>
<td>1.88*</td>
<td>1.24</td>
<td>1.40</td>
<td>09.02</td>
<td>0.46</td>
</tr>
<tr>
<td>100-kernel wt</td>
<td>87.69</td>
<td>11.97**</td>
<td>6.08</td>
<td>4.96</td>
<td>08.82</td>
<td>0.66</td>
</tr>
<tr>
<td>Grain yield</td>
<td>236500.03</td>
<td>947509.62*</td>
<td>420935.5</td>
<td>622686</td>
<td>18.46</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Short stature plants were observed for HS-101 (140 cm) whereas taller plants were common in HS-67 (192 cm). Moderate heritability estimate of 0.58 was observed for plant height (Table I). For ear height, minimum value (48 cm) was observed for HS-98 while maximum value (97.5 cm) was recorded for HS-78 (Table II). Heritability estimate of 0.62 was observed for this parameter (Table I). Ojo et al. (2006) and Mahmood et al. (2004) reported heritability estimates of 0.45 and 0.99, respectively for plant height in maize. Plant and ear height were having a positive and highly significant correlation of similar magnitude with grain yield (Table III).

**Ear Length (cm)**

Maize ear-length is a primary yield component affecting the net grain yield of maize plant. Statistical analysis of the data regarding ear length revealed highly significant genetic variation (P≤ 0.01) among the half sib families used in this study. Carlone and Russel (1989) obtained significant differences for ear length among testcrosses of maize synthetic 'BSSS' lines. Coefficient of variation (CV) for ear length was 9.73 % (Table I). Maximum ear length (18 cm) was recorded for HS-2, while minimum was obtained for HS-77, HS-20 and HS-32 (Table III). Heritability estimate of ear length was 0.50 which can be classified as moderate in nature (Table I). Mahmood et al. (2004) reported the heritability estimate of 0.85 for ear length in maize genotypes. There was a positive and highly significant correlation (0.38) between ear length and grain yield (Table III).
Table III  Correlation coefficients of days to pollen shedding and silking, plant and ear height, kernel rows per year and ear length with grain yield

<table>
<thead>
<tr>
<th>Character</th>
<th>Days to anthesis</th>
<th>Anthesis silking interval</th>
<th>Plant height</th>
<th>Ear height</th>
<th>Ear length</th>
<th>Kernel rows cob(^{-1})</th>
<th>100 grain weight</th>
<th>Grain yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.86**</td>
<td>0.19**</td>
<td>0.00NS</td>
<td>0.10NS</td>
<td>0.04NS</td>
<td>0.12*</td>
<td>-0.17**</td>
<td>0.09NS</td>
</tr>
<tr>
<td>Days to silking</td>
<td>0.67**</td>
<td></td>
<td>0.02NS</td>
<td>0.12*</td>
<td>0.07NS</td>
<td>0.14*</td>
<td>-0.24**</td>
<td>0.03NS</td>
</tr>
<tr>
<td>Anthesis silking interval</td>
<td></td>
<td></td>
<td>0.04NS</td>
<td>0.08NS</td>
<td>0.07NS</td>
<td>0.09NS</td>
<td>-0.21**</td>
<td>-0.06NS</td>
</tr>
<tr>
<td>Plant height</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.08NS</td>
<td>0.24**</td>
</tr>
<tr>
<td>Ear height</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.14*</td>
<td>0.27**</td>
</tr>
<tr>
<td>Ear length</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.03NS</td>
<td>0.11NS</td>
</tr>
<tr>
<td>Kernel rows cob(^{-1})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.07NS</td>
<td>0.13*</td>
</tr>
<tr>
<td>100 grain weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.07NS</td>
<td>0.13*</td>
</tr>
</tbody>
</table>

NS = Non significant  
* = Significant at 5% level of significance  
** = Significant at 1% level of significance

Kernel Rows Ear\(^{-1}\)

Kernel rows ear\(^{-1}\) is an important yield parameter which can significantly contribute to the grain yield and ultimately total grain production. Data regarding kernel rows ear\(^{-1}\) showed significant variation (P ≤ 0.05) among the half sib families. Our results are supported by the findings of Saleem et al. (2007) who observed highly significant differences among the genotypes for kernel rows ear\(^{-1}\). Coefficient of variation (CV) for kernel rows ear\(^{-1}\) was 9.02% (Table I). Minimum kernel rows ear\(^{-1}\) (11) was observed for HS-9, HS-72, HS-102 and HS-138, while maximum (16) was obtained for HS-12 and HS-113 (Table II). Moderate heritability estimate of 0.46 was manifested for this parameter (Table I). Contrary to our results, Mahmood et al. (2004) reported high heritability estimate of 0.87 for kernel rows ear\(^{-1}\). The difference in results might be attributable to the variations in the environment being encountered in the two studies. Kernel rows ear\(^{-1}\) was positively correlated with grain yield, days to pollen shedding and silking while non-significantly with plant and ear height, ear length, anthesis silking interval and 100 kernel weight (Table III). Kernel rows ear\(^{-1}\) is the most important yield component and greater number of kernel rows ear\(^{-1}\) is associated with higher grain yield (Rahman et al., 2007). As a component of grain yield, kernel rows ear\(^{-1}\) has a positive relationship with grain yield and is usually given special consideration in maize improvement programs.

100 Kernel Weight (g)

Data pertaining to 100 kernel weight, revealed highly significant differences (P ≤ 0.01) among the half sib families (Table I). Rahman et al. (2007) also reported significant differences for this trait while comparing original and selected maize populations for grain yield traits. Coefficient of variation was 8.82%. Minimum 100 seed weight (20g) was recorded for HS-84 whereas maximum (33.63g) was observed for HS-93 (Table II). A moderate heritability estimate of 0.66 was observed for 100 kernel weight (Table I). Sujiprihati et al. (2003) reported a high heritability estimate of 0.80 for 100 kernel weight. Dash (1992) reported that 100 seed weight along with plant height and ear length is the major yield contributing factor and is important parameter for selection. Significant and positive correlation of lower magnitude (0.16) was observed for grain yield and 100 kernels weight (Table III), which is in agreement with the results of Eleweanya et al. (2005).

Grain Yield (kg ha\(^{-1}\))

Grain yield improvement is one of the major aims of maize breeding programs. Statistical analysis of the data regarding ear length revealed highly significant genetic variation (P ≤ 0.01) among the half sib families. Our results are consistent with that of Tanner and Smith (1987) who conducted eight cycles of half-sib family and S<sub>i</sub> progeny recurrent selection in cv. Krug and obtained significant variances among testcrosses for grain yield.

HS-51 showed the maximum grain yield (6987 kg ha\(^{-1}\)) while HS-102 was the lowest in performance, with grain yield of 2269 kg ha\(^{-1}\) (Table II). Moderate heritability estimate of 0.51 was observed for grain yield (Table I). Akbar et al. (2008) and Ojo et al. (2006) reported a high heritability (h<sup>2</sup>) estimate of 0.82 and 0.99 for this trait, respectively. Low heritability value for grain yield is usually common because of involvement of large number of genes and high influence of environmental interaction (Welsh, 1981). Positive correlation was observed among grain yield and other traits observed in this study, except anthesis silking interval (Table III). Eleweanya et al. (2005) obtained negative correlation between grain yield and days to mid silking while Akbar et al. (2008) reported negative phenotypic correlation between grain yield and ear height in maize.
CONCLUSION AND RECOMMENDATIONS

HS-51, followed by HS-143, HS-39, HS-33, HS-114, HS-44, and HS-7 gave the highest grain yield. Therefore, these lines could be further evaluated in test cross combinations to test their relative potential as parents in future maize breeding schemes. Twenty seven half-sib families were observed protogynous. Such lines can be used to develop hybrids for maize growing areas having short growing seasons. HS-55, HS-111, HS-7, HS-134 and HS-49 were having medium plant height and HS-13, HS-128, HS-21, HS-7, HS-46, HS-31, HS-54 and HS-137 had top ear located at central position of the plant and had the potential of promising half-sib progenies for lodging resistance. Heritability estimates of all the traits were medium to high which shows considerable environmental influence in the expression of these plant characters.

REFERENCES


