Genetic Analysis of Six Parental Sesame Genotypes for Yield and Its Attributes in F1 Crosses

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ABSTRACT

To identify superior hybrids and create desirable combinations, a half diallel set involving six parental sesame genotypes was conducted in 2014 season. Six parental sesame genotypes and their 15 F1 crosses were evaluated at Bahteen Research Station in summer season 2015 using randomized complete block design with three replications. Genotypes and its components (parents, hybrids and parents vs. hybrids) mean squares were highly significant for all studied traits. General (GCA) and specific (SCA) combining ability mean squares were highly significant for all studied traits.

Also, additive gene action was governed in most studied traits. The best combiners for seed yield/plot and one or more of its components were detected NA.77 (P3) and NA.78 (P4). The highest heterotic effects over mid and better parents were detected in F1 hybrids, NA.80 x NA.35 (P1 xP5) and NA.80 x NA.40 (P1 xP6) for seed yield/plot and seed yield/plot and one or more of its attributes. Significant or highly significant values and high values of the dominance component (H/D) were also observed for the most studied trait, indicating that the presence of over-dominance and its confirmed by (H/D)⁰·⁵ (more than 1).

The effective selection and high narrow sense heritability were detected for days to 50% flowering (62%), days to physiological maturity (77%) ranging from 62 to77. The parents of NA.77 (P3), NA.59 (P2), NA.78 (P4) carried the most dominance genes responsible for the expression of seed yield/plot and plot in contrary NA.80 and NA.35 for seed yield/plot possessed high concentration of recessive genes.

Key words: Sesame, Sesamum indicum, Half diallel analysis, Heterosis, Combining ability, Gene action.

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1. INTRODUCTION

Sesame (Sesamum indicum L.) is one of the most important oil seed crops with high oil content, rich nutritive value but also for the quality and quantity (42-59%) of its oil which is rich in vitamin E and has a significant amount of Linoleic acid that can control blood cholesterol levels. The present sesame varieties under cultivation have limited yield potential as most of the varieties evolved and released for cultivation, are selection from local or closely related population [17].

Therefore, to establish a sound basis for achieving high yield of sesame, great attention must be given to detect information on heterotic effects, Per se performance, general and specific combining ability effects of parents along with genetic components of variance for yield and associated traits.

The heterotic effects helps the breeders to identify the desirable hybrids either had significantly positive for yield and yield attributing traits or significantly negative for earliness traits depending on the genetic potential of parents. Combining ability analysis of [3] is most widely used as biometrical tool by diallel analysis to identify the best combiners which may be hybridized either to exploit heterosis or to build up the favorable fixable genes. Moreover, the half diallel analysis developed by [4]; [5] and
[6] also provide the breeders with detailed information about the type of gene action and genetic system, which helps the breeder in the selection of desirable parents for crossing programs and in deciding a suitable breeding procedure for genetic improvement of various quantitative traits. A suitable breeding methodology and the identification of superior parents are the most important pre-requisites for the development of early maturing and high yielding genotypes.

For genetic improvement of the crop, combining ability analysis has been utilized to know the nature and extent of gene action controlling expression of different characters including seed yield and would help in proper planning of a successful breeding programme. Several workers used combining ability analysis in sesame and identified superior combining parents [22]; [16]; [13]. Genetic diversity or allelic divergence among the parents is very important in selecting parents for hybridization programme to identifying heterotic crosses and obtaining desirable recombinants in the segregating generations. The mean square for the GCA was higher than the mean square due to SCA for all the traits [19].

This revealed importance of both additive and non-additive gene actions in the characters. The objectives of the present study are development and identification of superior hybrids. Using Parents with best general and specific combining ability is utilized as donors for improvement of traits. Crosses with specific combining ability and heterosis for seed yield and oil quality with a view to incorporate them in breeding programme for further improvement. The nature of gene action is responsible for controlling genetic expression of the studied traits.

2. MATERIALS AND METHODS

In successive an attempt to genetic improvement of sesame, six genetically diverse parental sesame genotypes namely, NA.80 (P1), NA.59 (P2), NA.77 (P3), NA.78 (P4), NA.35 (P5) and NA.40 (P6) which received from Department of Genetic Resources Research, Field Crop Research Institute, Agricultural Research Center Egypt, were crossed by hand emasculation and pollination using half diallel mating design excluding reciprocals during 2014 summer successive season in an attempt to produce sufficient of seeds for 15 F1 crosses at kafr-El-Hamam Agricultural Research Station, ARC, Zagazig, Sharkia governorate, Egypt.

In 2015 successive summer growing season, seeds of six parents along with their 15 F1 crosses were evaluated at Bahteam Agricultural Research Station is located at 30° 14’ N for Latitude and 31° 27’ E for Longitude which is high fertility clay loam soil. The experimental design was arranged as a randomized complete block design with three replications, where each entry either parents or their 15 F1 hybrids were contiguous sown without leaving separators in three ridges with 4 m long, 0.60 cm broad and plants spaced 20 cm with in ridge. All other agricultural practices for growing sesame either soil preparation, soil fertilization or cultivation followed by recommended packages.

The measurements were recorded for days to 50% flowering and days to physiological maturity (based on all plants/experimental unit), plant height, fruiting zone length, first capsule height, No. of branches/plant, No. of capsules/plant, thousand seed weight and seed yield/plot (based on ten competitive plants/plot). Seed oil content was determined after extraction with soxhlet’s apparatus using hexane as an organic solvent according to [1]. Seed yield/plot (kg) was estimated from the plants in the central area being 2.7 m² in each experimental plot.

following [20] modification. Validity of assumptions in [4]; [5] and [6] model was tested using two scaling test i.e. uniformity of Wr-Vr (t² test) and regression analysis of Wr/Vr. A graphical analysis [4]; [6] was performed to determine the frequency of dominant and recessive alleles in the parental sesame genotypes. Genetic components along with related genetic parameters were estimated according to [5].

The mean squares parents vs. crosses were highly significant for all studied trait, indicating presence of sufficient amount of heterosis among hybrids. This was confirmed by the values of mean deviation of F1’s from the mid parents (b1) [20] in Table (2) which were highly significant for all studied traits.

The significant or highly significant of b2 values were obtained for all traits, except physiological maturity and number of branches/plant indicating asymmetry of gene distribution for these traits. Finally, item b3 was highly significant for all studied traits indicating the existence of inconsistent allelic and non-allelic interaction or dominance effects specific to individual crosses for all traits [14]; [7].
(Table 1): Mean squares of six sesame parents and their F\textsubscript{1} season crosses for earliness, yield and its attributes traits in 2015

<table>
<thead>
<tr>
<th>SOV</th>
<th>Reps</th>
<th>Genotypes</th>
<th>Parents(P)</th>
<th>Crosses©</th>
<th>P. V. C.</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Df</td>
<td>2</td>
<td>20</td>
<td>5</td>
<td>14</td>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td>Days to 50% flowering, day</td>
<td>0.59</td>
<td>29.65**</td>
<td>30.76**</td>
<td>27.10**</td>
<td>59.74**</td>
<td>3.05</td>
</tr>
<tr>
<td>Physiological maturity, day</td>
<td>0.51</td>
<td>67.42**</td>
<td>90.40**</td>
<td>59.49**</td>
<td>63.44**</td>
<td>4.24</td>
</tr>
<tr>
<td>Plant height, cm</td>
<td>2.24</td>
<td>932.58**</td>
<td>403.26**</td>
<td>600.91**</td>
<td>8222.43**</td>
<td>19.76</td>
</tr>
<tr>
<td>First capsule height, cm</td>
<td>55.73</td>
<td>985.72**</td>
<td>2191.30**</td>
<td>594.70**</td>
<td>423.07</td>
<td>143.99</td>
</tr>
<tr>
<td>Fruiting zone</td>
<td>11.625</td>
<td>391.973**</td>
<td>716.962**</td>
<td>203.650**</td>
<td>1403.554</td>
<td>5.308</td>
</tr>
<tr>
<td>Number of branches/plant</td>
<td>0.67</td>
<td>1.25**</td>
<td>1.43**</td>
<td>0.72**</td>
<td>7.76**</td>
<td>0.32</td>
</tr>
<tr>
<td>Number of capsules/plant</td>
<td>10.78</td>
<td>3556.42**</td>
<td>2098.89**</td>
<td>3269.37**</td>
<td>14862.86**</td>
<td>11.03</td>
</tr>
<tr>
<td>1000-seed weight,(g)</td>
<td>0.01</td>
<td>0.11**</td>
<td>0.19**</td>
<td>0.08**</td>
<td>0.05**</td>
<td>0.01</td>
</tr>
<tr>
<td>Seed yield/plant,(g)</td>
<td>2.73</td>
<td>331.35**</td>
<td>737.08**</td>
<td>168.90**</td>
<td>577.02**</td>
<td>5.24</td>
</tr>
<tr>
<td>Seed yield/plot,(kg)</td>
<td>4061.03</td>
<td>8503.02**</td>
<td>9973.18**</td>
<td>12065.86**</td>
<td>130258.65**</td>
<td>23714.71</td>
</tr>
</tbody>
</table>

Where; *=P<0.05 and **=P<0.01

(Table 2): Jones analysis of combining ability mean squares in six sesame parents and their F\textsubscript{1} crosses for earliness, yield and its attributes in 2015 season

<table>
<thead>
<tr>
<th>SOV</th>
<th>A</th>
<th>b\textsubscript{1}</th>
<th>b\textsubscript{2}</th>
<th>b\textsubscript{3}</th>
<th>B</th>
<th>Total</th>
<th>AxB</th>
<th>b\textsubscript{1}XB</th>
<th>b\textsubscript{2}XB</th>
<th>b\textsubscript{3}XB</th>
<th>bxB Total xB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Df</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>9</td>
<td>15</td>
<td>20</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>Days to 50% flowering, (day)</td>
<td>25.63**</td>
<td>19.91**</td>
<td>2.85</td>
<td>3.93**</td>
<td>4.64**</td>
<td>9.88**</td>
<td>0.62</td>
<td>2.74</td>
<td>1.45</td>
<td>0.8</td>
<td>1.15</td>
</tr>
<tr>
<td>Physiological maturity, (day)</td>
<td>72.32**</td>
<td>21.15**</td>
<td>1.93</td>
<td>6.34**</td>
<td>5.86**</td>
<td>22.47**</td>
<td>2.16</td>
<td>0.66</td>
<td>0.99</td>
<td>1.32</td>
<td>1.17</td>
</tr>
<tr>
<td>Plant height,(cm)</td>
<td>204.65*</td>
<td>2740.81**</td>
<td>76.93*</td>
<td>229.83**</td>
<td>346.26**</td>
<td>310.86**</td>
<td>6.47</td>
<td>0.45</td>
<td>9.28</td>
<td>5.84</td>
<td>6.63</td>
</tr>
<tr>
<td>First capsule height,(cm)</td>
<td>665.20*</td>
<td>144.2</td>
<td>283.33</td>
<td>187.20</td>
<td>216.36**</td>
<td>328.57**</td>
<td>79.83</td>
<td>121.3</td>
<td>83.87</td>
<td>2.227</td>
<td>37.39</td>
</tr>
<tr>
<td>Fruiting zone</td>
<td>180.41*</td>
<td>467.85*</td>
<td>132.43</td>
<td>64.57*</td>
<td>114.07**</td>
<td>130.66**</td>
<td>1.9</td>
<td>1.99</td>
<td>2.14</td>
<td>1.47</td>
<td>1.73</td>
</tr>
<tr>
<td>Number of branches/plant</td>
<td>0.28*</td>
<td>2.59**</td>
<td>0.24</td>
<td>0.35**</td>
<td>0.46**</td>
<td>0.42**</td>
<td>0.09</td>
<td>0.11</td>
<td>0.06</td>
<td>0.15</td>
<td>0.11</td>
</tr>
<tr>
<td>Number of capsules/plant</td>
<td>410.13*</td>
<td>4954.29**</td>
<td>932.11</td>
<td>1338.22</td>
<td>1443.9**</td>
<td>1185.47**</td>
<td>2.99</td>
<td>2.88</td>
<td>3.79</td>
<td>4.08</td>
<td>3.9</td>
</tr>
<tr>
<td>1000-seed weight,(g)</td>
<td>0.053**</td>
<td>0.17**</td>
<td>0.034*</td>
<td>0.031*</td>
<td>0.031*</td>
<td>0.036</td>
<td>0.001</td>
<td>0.002</td>
<td>0.004</td>
<td>0.002</td>
<td>0.002</td>
</tr>
<tr>
<td>Seed yield/plant,(g)</td>
<td>2.11.19*</td>
<td>192.34*</td>
<td>100.56</td>
<td>50.88*</td>
<td>76.87*</td>
<td>110.45**</td>
<td>1.3</td>
<td>1.08</td>
<td>1.95</td>
<td>1.96</td>
<td>1.9</td>
</tr>
<tr>
<td>Seed yield/plot,(g)</td>
<td>138717.29*</td>
<td>376752.88*</td>
<td>50460.03*</td>
<td>79190.03*</td>
<td>42784.22*</td>
<td>16767.48*</td>
<td>5349.03</td>
<td>5927.42</td>
<td>8601.57</td>
<td>9157.52</td>
<td>8756.86</td>
</tr>
</tbody>
</table>
flowering and days to physiological maturity were (P<0.01). Significant negative direction of heterosis and heterobeltiosis are desirable goal for the earliness traits, days to 50% flowering and days to physiological maturity to produce high yield in a short period especially intensive cropping systems.

The early physiological maturity character is dependent on a minor gene complex. These are also very valuable source for plant breeding programmes aiming for adaptation of sesame to different environments as well as for studied on thermo and photo-period sensitivity. These results are in agreement with [15].

Also, short plant height and first capsule height are suitable for mechanical harvesting and lodging resistance. Several hybrids had high negative heterosis values over both mid and better parents for earliness characters. The most promising hybrids for earliness in flowering were (P<0.01) in mid parent, while hybrid (P<0.01) is better parent. While for earliness in maturity, the best hybrids were (P<0.01) as seen in (Table 4). The desirable hybrids for plant height were (P<0.01) and (P<0.01) in mid parent and better parent respectively. The best hybrids for fruiting zone length were (P<0.01). For yield and its components as well as seed oil content characters, the significant positive heterotic values over mid and better parent are preferred.

As shown from the results in Table (4), the best hybrids for number of branches/plant were (P<0.01). The desirable hybrids for number of capsules/plant were (P<0.01) and (P<0.01) in mid parent and better parent. For first capsule height, the best hybrids were (P<0.01) and (P<0.01) respectively. The best hybrids for fruiting zone length were (P<0.01 X P<0.01). For yield and its components as well as seed oil content characters, the significant positive heterotic values over mid and better parent are preferred.

<table>
<thead>
<tr>
<th>Trait</th>
<th>DF</th>
<th>GCA</th>
<th>SCA</th>
<th>Error</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to 50% flowering (day)</td>
<td>5</td>
<td>25.63**</td>
<td>4.64**</td>
<td>1.02</td>
<td>*</td>
</tr>
<tr>
<td>Physiological maturity (day)</td>
<td>15</td>
<td>72.32**</td>
<td>5.86**</td>
<td>1.41</td>
<td>*</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>346.26**</td>
<td>6.59</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First capsule height (cm)</td>
<td>216.36**</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruiting Zone</td>
<td>114.07**</td>
<td>1.77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of branches/plant</td>
<td>0.46**</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of capsules/plant</td>
<td>1443.92**</td>
<td>3.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000-seed weight (g)</td>
<td>0.03**</td>
<td>0.002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed yield/plant (g)</td>
<td>76.87**</td>
<td>1.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed yield/plant (kg)</td>
<td>142784.22**</td>
<td>7904.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed oil content (%)</td>
<td>9.70**</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where: *=P<0.05 and **=P<0.01

2-Heterotic effects:

To draw the valid conclusions respecting the amount of heterosis for various traits, the percentage of deviation of F<sub>1</sub> mean performance from the mid parents (average heterosis) and better parents (heterobeltiosis) were computed as shown in Table (4). Significant negative direction of heterosis and heterobeltiosis are desirable goal for the earliness traits, days to 50% flowering and days to physiological maturity to produce high yield in a short period especially intensive cropping systems.

The early physiological maturity character is dependent on a minor gene complex. These are also very valuable source for plant breeding programmes aiming for adaptation of sesame to different environments as well as for studied on thermo and photo-period sensitivity. These results are in agreement with [15].

Also, short plant height and first capsule height are suitable for mechanical harvesting and lodging resistance. Several hybrids had high negative heterosis values over both mid and better parents for earliness characters. The most promising hybrids for earliness in flowering were (P<0.01 X P<0.01) in mid parent, while hybrid (P<0.01) is better parent. While for earliness in maturity, the best hybrids were (P<0.01) as seen in (Table 4). The desirable hybrids for plant height were (P<0.01) and (P<0.01) in mid parent and better parent. For first capsule height, the best hybrids were (P<0.01) and (P<0.01) respectively. The best hybrids for fruiting zone length were (P<0.01). For yield and its components as well as seed oil content characters, the significant positive heterotic values over mid and better parent are preferred.

As shown from the results in Table (4), the best hybrids for number of branches/plant were (P<0.01). The desirable hybrids for number of capsules/plant were (P<0.01) and (P<0.01) in mid parent and better parent. For first capsule height, the best hybrids were (P<0.01) and (P<0.01) respectively. The best hybrids for fruiting zone length were (P<0.01). For yield and its components as well as seed oil content characters, the significant positive heterotic values over mid and better parent are preferred.
3-Per se performance associated with combining ability:

3-1-Performance and general combining ability effects (GCA):

It is clear from the results in Tables (5) and (6), that the earliest parents for days to 50% flowering and days to physiological maturity were P1. This finding confirmed by negative and highly significant GCA effects of the parent, indicating the parent possessed more decreasing alleles towards earliness.
(Table 4): Heterosis (%) of fifteen sesame F_1 crosses over both mid parent (M.P.) and better parent (B.P.) for earliness, yield and its attributes in 2015 season

<table>
<thead>
<tr>
<th>Crosses</th>
<th>P_1 X P_2</th>
<th>P_1 X P_3</th>
<th>P_1 X P_4</th>
<th>P_1 X P_5</th>
<th>P_2 X P_4</th>
<th>P_2 X P_5</th>
<th>P_3 X P_4</th>
<th>P_3 X P_5</th>
<th>P_4 X P_5</th>
<th>P_5 X P_6</th>
<th>LSD %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to 50% flowering</td>
<td>12.96*</td>
<td>6.57*</td>
<td>5.80**</td>
<td>10.65</td>
<td>0.32</td>
<td>0.63</td>
<td>6.25**</td>
<td>7.45**</td>
<td>-2.97*</td>
<td>-1.64</td>
<td>-4.89**</td>
</tr>
<tr>
<td></td>
<td>3.68**</td>
<td>8.09**</td>
<td>-0.74</td>
<td>14.7</td>
<td>5.33**</td>
<td>4.58**</td>
<td>-3.23*</td>
<td>-5.10**</td>
<td>-2</td>
<td>0</td>
<td>-3.92**</td>
</tr>
<tr>
<td>Physiologic maturity</td>
<td>0.6</td>
<td>3.77*</td>
<td>3.99**</td>
<td>-0.44</td>
<td>-0.08</td>
<td>3.89*</td>
<td>-0.25</td>
<td>-1.79</td>
<td>3.79*</td>
<td>2.91</td>
<td>3.54*</td>
</tr>
<tr>
<td></td>
<td>1.91</td>
<td>8,45**</td>
<td>8,73**</td>
<td>6.22**</td>
<td>2.4</td>
<td>7.92**</td>
<td>3.67*</td>
<td>0.05</td>
<td>10.06*</td>
<td>2.95</td>
<td>5.54**</td>
</tr>
<tr>
<td></td>
<td>16.64*</td>
<td>15.86*</td>
<td>17.24*</td>
<td>29.1</td>
<td>11.55*</td>
<td>16.18*</td>
<td>23.19*</td>
<td>17.57*</td>
<td>26.41*</td>
<td>10.23*</td>
<td>13.94*</td>
</tr>
<tr>
<td>First capsule height</td>
<td>13.31</td>
<td>46.00*</td>
<td>-15.12</td>
<td>16.91</td>
<td>0.19</td>
<td>10.13</td>
<td>7</td>
<td>3.56</td>
<td>21.64*</td>
<td>-18.43*</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>-5.25</td>
<td>33.77*</td>
<td>36.96*</td>
<td>11.78</td>
<td>-6.66</td>
<td>-0.46</td>
<td>-7.88</td>
<td>-7.88</td>
<td>5.65</td>
<td>-35.43*</td>
<td>-0.69</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-30.73*</td>
</tr>
<tr>
<td></td>
<td></td>
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Where: *P<0.05 and **P<0.01
There was a close correspondence between *per se* performance and GCA effects, relative to $P_5$ was the shortest parents and identified as desirable ones for both plant height and first capsule height, showed the $P_1$ the near surface of soil. Fruiting zone length the analysis revealed that the $P_1$ the tallest plant. The first order of parents were $P_4$ and $P_6$ for number of branches/plant, and $P_3$ for number of capsules/plant, $P_4$ and $P_2$ for thousand seed weight, $P_2$ for seed yield/plant, and $P_3$ and $P_4$ for seed yield/plot and $P_1$ seed oil content. However, the considerable positive GCA effects were achieved by $P_4$ for number of branches/plant, $P_3$ for number of capsules/plant, $P_4$ and $p_2$ for thousand seed weight, $P_2$ for seed yield/plant, $P_3$ and $P_4$ for seed yield/plot and $P_1$ seed oil content. To determine combining ability of parents in the early generation, the genetic diversity or allelic divergence among the parents is very important in selection parents for hybridization programme to identifying heterotic crosses and obtaining desirable recombinants in the segregating generation. Significant variation for yield and yield related traits were reported by [23] and [8].

Table 5: Mean performance of sesame parents and their $F_1$ crosses for earliness, yield and its attributes traits in 2015 season

<table>
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<tr>
<th>Crossovers</th>
<th>Days to 50% flowering, day</th>
<th>Physiological maturity, day</th>
<th>Plant height, cm</th>
<th>First capsule height, cm</th>
<th>Fruiting Zone</th>
<th>Number of branches/Plant</th>
<th>Number of capsules/plant</th>
<th>1000-seed weight, (g)</th>
<th>Seed yield/plant, (g)</th>
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LSD

|       |       |       |       |       |
|-------|-------|-------|-------|
| 5%    | 1.29  | 1.52  | 3.28  |
|       | 8.86  | 1.7   | 0.42  |
|       | 1.7   | 2.45  | 0.07  |
|       |       | 1.69  | 113.65|
| 1%    | 1.72  | 2.03  | 4.39  |
|       | 11.85 | 2.28  | 0.56  |
|       |       | 3.28  | .01   |
|       |       | 2.26  | 152.08|
|       |       |       | 0.48  |

Where: *=P<0.05 and **=P<0.01
(Table 6): General combining ability effects of six sesame parents for earliness yield and its attributes in 2015 season

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<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
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<th>LSD 1%</th>
<th>LSD 5%</th>
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<td>Fruiting zone</td>
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<tr>
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<td>-10.07**</td>
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<td>1000-seed</td>
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<td>0.01</td>
<td>0.15**</td>
<td>0.01</td>
<td>-0.08**</td>
<td>0.03</td>
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<td>0.08</td>
<td>0.11</td>
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<tr>
<td>Seed yield/plant</td>
<td>-5.65**</td>
<td>0.4</td>
<td>6.80**</td>
<td>5.39**</td>
<td>4.01**</td>
<td>2.94**</td>
<td>0.86</td>
<td>1.15</td>
<td>2.37</td>
<td>3.17</td>
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<td>Seed yield/plot</td>
<td>429.63**</td>
<td>20.64</td>
<td>491.16**</td>
<td>403.15**</td>
<td>293.38**</td>
<td>191.94**</td>
<td>58</td>
<td>77.61</td>
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<td>Seed oil</td>
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<td>2.92**</td>
<td>0.66**</td>
<td>0.72**</td>
<td>1.98**</td>
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</table>

Where; *=P<0.05 and **=P<0.01

### 3-2-Performance and specific combining ability effects (SCA):

It is worthy to appear as shown in Tables 5 and 7 that some correspondence between performance and SCA effects for the most traits. Concerning the performance of all genotypes (Table 5), the data show that the earliest cross combinations were (P1 x P3) and (P1 x P2) for days to 50% flowering and (P1 x P2) for days to physiological maturity, respectively the hybrids in (p1 x p2) the earliest in days to 50% flowering and physiological maturity is dependent on a minor gene complex.

The shortest hybrids were (P2 x P6) for plant height and (P1 x P3) for first capsule height and (p4 x p5) for the fruiting zone length. The best cross combinations were (P1 x P4) and for number of branches/plant, (P2 x P3) and (P1 x P6) for number of capsules/plant, (P3 x P4) and (P4 x P3) for thousand seed weight, (P1 x P3) for seed yield/plant, (P1 x P4) and (p1 x p3) also seed yield/plot the best crosses (P1 x P4) for seed oil content. The specific combining ability values (SCA) of hybrids are presented in Table (7). The earliest crosses due to SCA effects were (P1 x P2) for days to 50% flowering, (P2 x P3) for days to physiological maturity respectively.

The shortest crosses were (P4 x P3) for plant height and (P4 x P3) for first capsule height, respectively. The valuable positive SCA effects were detected in (P4 x P3) in fruiting zone length and (P3 x P3) and (P1 x P2) for number of branches/plant, (P2 x P3) and (P1 x P6) for number of capsules/plant, (P3 x P4) and (P4 x P3) for thousand seed weight, (P1 x P3) for seed yield/plant, (P1 x P3) for seed yield/plot and (P2 x P3) for seed oil content, in respective order. The SCA represents the dominance and epistasis, which can be associated with heterobeltiosis [21].

It is therefore suggested that SCA performance might be considered as a criterion for selecting the best crosses. A perusal of F1’s hybrids revealed that (P1 x P5) for seed/plant, (P1 x P3) for seed yield/plot and (P1 x P2) for earliness and yield attributing traits were identified as the best crosses since they possessed desirable per se performance, SCA effects along with mid and better parent heterosis.

(Table 9): Specific combining ability effects of fifteen sesame F1 crosses for earliness, yield and its attributes across in 2015 season
<table>
<thead>
<tr>
<th>Crosses</th>
<th>Days to 50% flowering</th>
<th>Physiological maturity</th>
<th>Plant height</th>
<th>First capsule height, cm</th>
<th>Fruiting Zone</th>
<th>Number of branches/plant</th>
<th>Number of capsules/plant</th>
<th>1000-seed weight</th>
<th>Seed yield/plant</th>
<th>Seed yield/plot</th>
<th>Seed oil content</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 X P2</td>
<td>3.95**</td>
<td>-0.14</td>
<td>5.29**</td>
<td>2.69</td>
<td>0.21</td>
<td>-0.35</td>
<td>20.37*</td>
<td>0.10*</td>
<td>-5.8</td>
<td>-114.17</td>
<td>-2.65*</td>
</tr>
<tr>
<td>P1 X P3</td>
<td>2.64**</td>
<td>2.18*</td>
<td>4.33*</td>
<td>25.78</td>
<td>10.46*</td>
<td>-0.30</td>
<td>27.24*</td>
<td>-0.01</td>
<td>-9.45**</td>
<td>700.49**</td>
<td>-2.35*</td>
</tr>
<tr>
<td>P1 X P4</td>
<td>-1.40</td>
<td>2.66*</td>
<td>6.90**</td>
<td>-10.42</td>
<td>9.06**</td>
<td>0.77*</td>
<td>32.51*</td>
<td>-0.08*</td>
<td>6.46**</td>
<td>533.23**</td>
<td>1.06*</td>
</tr>
<tr>
<td>P1 X P5</td>
<td>-2.61**</td>
<td>-1.25</td>
<td>-3.29</td>
<td>-4.42</td>
<td>10.64*</td>
<td>0.53*</td>
<td>19.92*</td>
<td>0.04</td>
<td>18.54*</td>
<td>1386.85*</td>
<td>0.54*</td>
</tr>
<tr>
<td>P1 X P6</td>
<td>-0.53</td>
<td>-1.49</td>
<td>20.98**</td>
<td>1.54</td>
<td>0.15</td>
<td>0.40</td>
<td>55.78*</td>
<td>0.40*</td>
<td>8.21**</td>
<td>602.35**</td>
<td>1.78*</td>
</tr>
<tr>
<td>P2 X P3</td>
<td>1.10</td>
<td>2.54**</td>
<td>7.47**</td>
<td>0.90</td>
<td>-0.21</td>
<td>0.67*</td>
<td>30.01*</td>
<td>-0.23*</td>
<td>-2.54*</td>
<td>-173.94*</td>
<td>-2.16*</td>
</tr>
<tr>
<td>P2 X P4</td>
<td>1.72*</td>
<td>-1.86*</td>
<td>20.21**</td>
<td>12.96*</td>
<td>-0.69</td>
<td>0.74*</td>
<td>20.91*</td>
<td>-0.24*</td>
<td>-2.91**</td>
<td>187.58**</td>
<td>2.45*</td>
</tr>
<tr>
<td>P2 X P5</td>
<td>-1.15</td>
<td>-2.93**</td>
<td>0.22</td>
<td>-2.46</td>
<td>4.46**</td>
<td>0.17</td>
<td>64.17*</td>
<td>0.08</td>
<td>7.42**</td>
<td>593.17**</td>
<td>3.33*</td>
</tr>
<tr>
<td>P2 X P6</td>
<td>-2.07**</td>
<td>3.53**</td>
<td>10.47**</td>
<td>7.45</td>
<td>11.32*</td>
<td>0.03</td>
<td>-6.66**</td>
<td>0.00</td>
<td>-4.36**</td>
<td>287.76**</td>
<td>1.13*</td>
</tr>
<tr>
<td>P3 X P4</td>
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<td>0.57</td>
<td>2.41</td>
<td>-16.76</td>
<td>8.31**</td>
<td>-0.38</td>
<td>20.55*</td>
<td>0.17*</td>
<td>7.30**</td>
<td>548.52**</td>
<td>1.01*</td>
</tr>
<tr>
<td>P3 X P5</td>
<td>0.10</td>
<td>1.83</td>
<td>-5.21**</td>
<td>-5.23</td>
<td>1.46</td>
<td>1.02*</td>
<td>40.37*</td>
<td>0.05</td>
<td>-3.78**</td>
<td>232.52**</td>
<td>-0.09</td>
</tr>
<tr>
<td>P3 X P6</td>
<td>-1.82*</td>
<td>-1.07</td>
<td>24.12**</td>
<td>18.55**</td>
<td>6.65**</td>
<td>0.02</td>
<td>-9.87**</td>
<td>0.06</td>
<td>2.79**</td>
<td>230.22**</td>
<td>3.15*</td>
</tr>
<tr>
<td>P4 X P3</td>
<td>-0.95</td>
<td>3.89**</td>
<td>13.94**</td>
<td>-4.01</td>
<td>20.31*</td>
<td>-0.18</td>
<td>14.95*</td>
<td>0.14*</td>
<td>5.95**</td>
<td>443.02**</td>
<td>6.18*</td>
</tr>
<tr>
<td>P4 X P6</td>
<td>0.80</td>
<td>0.13</td>
<td>-23.34**</td>
<td>-19.12**</td>
<td>-2.50*</td>
<td>-0.61</td>
<td>21.55*</td>
<td>0.11*</td>
<td>-4.33**</td>
<td>312.15**</td>
<td>4.06*</td>
</tr>
<tr>
<td>P5 X P6</td>
<td>0.26</td>
<td>1.18</td>
<td>23.89**</td>
<td>19.18**</td>
<td>7.65**</td>
<td>0.82*</td>
<td>41.63*</td>
<td>-0.63*</td>
<td>-9.46**</td>
<td>719.13**</td>
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<td>LSD sj 5%</td>
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<td>1.76</td>
<td>3.80</td>
<td>10.25</td>
<td>1.97</td>
<td>0.49</td>
<td>2.84</td>
<td>0.07</td>
<td>1.95</td>
<td>131.52</td>
<td>0.42</td>
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<td>0.65</td>
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<td>6.86</td>
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<td>0.88</td>
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<td>0.12</td>
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<tr>
<td>LSD sj/sik 1%</td>
<td>3.61</td>
<td>4.25</td>
<td>9.18</td>
<td>24.79</td>
<td>4.76</td>
<td>1.17</td>
<td>6.86</td>
<td>0.16</td>
<td>4.73</td>
<td>318.08</td>
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<tr>
<td>LSD sj/ski 5%</td>
<td>2.50</td>
<td>2.94</td>
<td>6.35</td>
<td>17.15</td>
<td>3.29</td>
<td>0.81</td>
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</tr>
<tr>
<td>LSD sj/ski 1%</td>
<td>3.34</td>
<td>3.94</td>
<td>8.50</td>
<td>22.95</td>
<td>4.41</td>
<td>1.09</td>
<td>6.35</td>
<td>0.15</td>
<td>4.38</td>
<td>294.49</td>
<td>0.93</td>
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Where; *=P<0.05 and **=P<0.01
4-Types of gene action and heritability

4-1-Validity of hypothesis

For testing the validity of the major assumption, uniformity of Wr-Vr (t² test) and regression analysis were conducted underlying the genetic models seen in Table (8).

Table (8): Validity of hypothesis through t², Regression coefficient (b), t-values for b=0 and b=1, Wr+Vr and Wr-Vr of six sesame parents and their F₁’s crosses for earliness, yield and its attributes traits in 2015 season

<table>
<thead>
<tr>
<th>Character</th>
<th>t²</th>
<th>Regression coefficient (b)±SE</th>
<th>b=0</th>
<th>b=1</th>
<th>Wr+Vr</th>
<th>Wr-Vr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to 50% flowering</td>
<td>0.04</td>
<td>0.74+_0.29</td>
<td>2.50</td>
<td>0.90</td>
<td>815.17**</td>
<td>80.02</td>
</tr>
<tr>
<td>Days to physiological maturity</td>
<td>13.95*</td>
<td>0.80+_0.05</td>
<td>17.21*</td>
<td>4.25*</td>
<td>3909.89**</td>
<td>14.01</td>
</tr>
<tr>
<td>Plant height</td>
<td>11.85*</td>
<td>-0.10+_0.13</td>
<td>-0.74</td>
<td>8.23*</td>
<td>154699.95*</td>
<td>20869.64**</td>
</tr>
<tr>
<td>first capsule height</td>
<td>2.21</td>
<td>1.23+_0.46</td>
<td>2.67</td>
<td>-0.50</td>
<td>1967594.7</td>
<td>4</td>
</tr>
<tr>
<td>Fruiting zone length</td>
<td>0.002</td>
<td>0.55+_0.43</td>
<td>1.27</td>
<td>1.05</td>
<td>96889.52*</td>
<td>19197.86**</td>
</tr>
<tr>
<td>No. of branches</td>
<td>0.18</td>
<td>0.98+_0.25</td>
<td>3.89*</td>
<td>0.08</td>
<td>2.14**</td>
<td>0.70</td>
</tr>
<tr>
<td>No. of Capsule/plant</td>
<td>0.14</td>
<td>-0.47+_0.36</td>
<td>-1.30</td>
<td>4.08*</td>
<td>810315.03*</td>
<td>44189.43**</td>
</tr>
<tr>
<td>Thousand seed weight</td>
<td>0.46</td>
<td>0.49+_0.83</td>
<td>0.59</td>
<td>0.62</td>
<td>0.01**</td>
<td>0.002**</td>
</tr>
<tr>
<td>Seed yield/plant</td>
<td>1.06</td>
<td>0.21+_0.43</td>
<td>0.50</td>
<td>1.83</td>
<td>70297.24*</td>
<td>11701.32**</td>
</tr>
<tr>
<td>Seed yield/plot</td>
<td>0.02</td>
<td>0.19+_0.39</td>
<td>0.50</td>
<td>2.10</td>
<td>38684.770</td>
<td>92784836.78*</td>
</tr>
<tr>
<td>Seed oil content</td>
<td>1.45</td>
<td>1.17+_0.34</td>
<td>3.46*</td>
<td>-0.49</td>
<td>1804.51**</td>
<td>126.01**</td>
</tr>
</tbody>
</table>

Where; *=P<0.05 and **=P<0.01

The highly significant differences among twenty one sesame genotypes indicated that the parents possessed widely diverse traits and this diversity could be transmitted to the off spring and it permitted the genetic analysis of the data. The non-significance of t² test validated the use of simple additive dominance model for genetic analysis of all studied traits except days to physiological maturity and plant height in which uniformity of Wr-Vr (t² test) was significant or highly significant, except first capsules height and seed yield/plot indicating the presence of non-allelic interaction in the inheritance of these traits.

4-2-Graphical analysis:

Graphical analysis of the parent off spring covariance (Wr) and array variance (Vr) and their related statistics was made to get a clear picture about the inheritance for all studied traits (Table 8 and Figures 1-11). Additive-dominance model of inheritance was observed as regression coefficient (b) of (Wr/Vr) in significant departed from unity in first capsule height and seed yield/plot, indicating the presence of an inter-allelic interaction in the inheritance of these traits.

The regression line intercepted the positive side of Wr axis for days to 50% flowering, days to physiological maturity seed yield/plant and seed oil content, indicating the presence of partial dominance, while it passed below the point of origin for the rest of traits indicating presence of over dominance in the inheritance of these ones, over dominance model was pronounced as the regression line touched the Wr axis below origin point for days to 50% flowering, physiological maturity, plant height, thousand seed weight, fruiting zone length and seed yield per plant. In contrast, regression line cut the Wr axis above the origin point for the rest of traits, indicating the presence of partial dominance.

Over dominance was found for all traits, except days to physiological maturity, number of branches/plant and seed oil content. This was supported by significant or highly significant differences in the magnitude of the Wr-Vr values.
over arrays in all studied traits, except for days to 50% flowering, days to physiological maturity and number of branches, indicating the presence of either non-allelic gene interaction or epistatic effects. In the contrary, the analysis of the variance revealed highly significance (Wr+Vr) value (Table 9) for all studied traits, confirming the presence of non-additive genetic variation for all traits.

The contradiction between both types of analysis might be a logical result of the presence of complementary type of non-allelic interaction which inflated the ratios of \((H_1/D)^{1/2}\) and distorted the \((Vr, Wr)\) graphs [5]; [7]. The array points of parental genotypes were widely scattered for all traits, indicating presence of genetic diversity among the tested parents.

The parental following genotypes, \(P_1\) for earliness and physiological maturity first capsules height and fruiting zone, \(P_6\) the tallest plant height whereas, \(P_2\) for thousand seed weight and seed yield/plant, \(P_3\) and \(P_4\) seed yield/plot, \(P_1\) and \(P_5\) for seed oil content, seemed to possess the most dominant genes responsible for the expression of these traits which being closer to the origin of regression graph. In the contrary, the parent following genotype, which might be due to be farthest ones from the origin of regression graph.

![Fig (1) wr/vr graphs for days to 50% flowering](image1)

![Fig (2) wr/vr graphs for days to physiological maturity](image2)
Fig (3) wr/vr graphs for plant height

\[ y = -0.10x + 72.20 \]

Fig (4) wr/vr graphs for first capsule height
Fig (5) wr/ vr graphs for fruiting zone length

Fig (6) wr/vr graphs for No. of branches/plant
Fig (7) wr/vr graphs for No. of capsules/plant

Fig (8) wr/vr graphs for 1000 seed weight
Fig (9) wr/vr graphs for seed yield/plant

Fig (10) wr/vr graphs for seed yield/plot

Fig (11) wr/vr graphs for seed oil content %
4-3. Genetic components and related genetic parameters

With respect to genetic components estimated by the Hayman’s diallel analyses as presented in Table (9). The data revealed that the components of additive (D) and dominance (H1 & H2) effects were positive and significant or highly significant either in days to 50% flowering, days to physiological maturity, number of branches, 1000 seed weight and seed oil content, indicating that important of both additive and non-additive components in the inheritance of above traits.

The magnitude of dominance (H1 & H2) was significant or highly significant higher than additive components (D) for all traits except plant height, fruiting zone length, No. of capsules/plant, seed yield/plant and seed yield/plot, indicating that the presence of over-dominance for the previous traits. Value of H1 was greater than H2 except seed yield/plant and seed yield/plot indicating that frequency of gene distribution in the parents was unequal and that was also supported by the ratio of H2/4H1 (<0.25) which showing asymmetrical gene distribution at the loci in the parents showing dominance for all the traits.

The F value was positive for all traits except days to 50% flowering and physiological maturity. That indicated that the presence of higher number of dominant than recessive genes and it was confirmed by the high value of KD/KR for all traits except the above traits as shown in Table (10), for which negative value indicated presence of higher number of recessive than dominants genes. The overall dominance effects of heterozygous loci (h2) were found to be positive and significant or highly significant for all studied traits except, seed oil content, first capsules height and 1000 seed weight indicating that most of the dominant genes had positive effects. All estimates of environmental variance (E) were insignificant for all studied character, indicating that all character have not been greatly affected by environmental factors.

Table (9): Estimation of genetic components for earliness, yield and its attributes traits in 2015 season

<table>
<thead>
<tr>
<th>Genetic components</th>
<th>E</th>
<th>D</th>
<th>F</th>
<th>H1</th>
<th>H2</th>
<th>h2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to 50% flowering</td>
<td>0.98+0.92*</td>
<td>9.27+_2.43*</td>
<td>-2.82+_5.93</td>
<td>14.98+_6.16**</td>
<td>13.11+_5.50*</td>
<td>2.36+_3.70*</td>
</tr>
<tr>
<td>Physiological maturity</td>
<td>1.35+_0.59*</td>
<td>8.78+_1.57*</td>
<td>-8.56+_3.84</td>
<td>8.32+_3.9</td>
<td>7.51+_3.35*</td>
<td>2.95+_2.40*</td>
</tr>
<tr>
<td>Plant height</td>
<td>6.31+_39*</td>
<td>8.11+_0.43</td>
<td>5.67+_555.57</td>
<td>7.88+_225.7</td>
<td>3.71+_237.20</td>
<td>2.95+_159.67</td>
</tr>
<tr>
<td>First capsule height</td>
<td>5346.60+_43.21</td>
<td>84+_114.31*</td>
<td>7.21+_279.2</td>
<td>51.12+_290.20</td>
<td>20.34+_59.21</td>
<td>67.46+_174.67</td>
</tr>
<tr>
<td>Fruiting zone length</td>
<td>21.870+_16</td>
<td>17.12+_44.58</td>
<td>24.17+_108.910</td>
<td>23.18+_113.18</td>
<td>21.71+_101</td>
<td>4.4220+_6.8</td>
</tr>
<tr>
<td>Number of branches/plant</td>
<td>80.110.03**</td>
<td>36+_0.09**</td>
<td>46+_0.22</td>
<td>37+_0.22**</td>
<td>24+_0.20**</td>
<td>61+_0.13</td>
</tr>
<tr>
<td>Number of capsules/plant</td>
<td>3.67+_203</td>
<td>95.96+_537</td>
<td>75.93+_1312</td>
<td>9.69+_1364</td>
<td>3.60+_1218</td>
<td>9.07+_820.93</td>
</tr>
<tr>
<td>1000-seed weight</td>
<td>1.000+_0.01*</td>
<td>0.06+_0.01*</td>
<td>0.07+_0.03</td>
<td>0.13+_0.03</td>
<td>0.10+_0.03*</td>
<td>0.01+_0.02</td>
</tr>
<tr>
<td>Seed yield/plant</td>
<td>1.71+_16.77</td>
<td>3.99+_44.36</td>
<td>1.56+_108.390</td>
<td>5.26+_112.6</td>
<td>8.01+_100.5</td>
<td>23.72+_67.7</td>
</tr>
<tr>
<td>Seed yield/plot</td>
<td>2.94+_9485</td>
<td>6.65+_2509</td>
<td>90.73+_6130</td>
<td>5.41+_6370</td>
<td>9.57+_5691</td>
<td>1.53+_3830S</td>
</tr>
<tr>
<td>Seed oil content</td>
<td>0.08+_1.42</td>
<td>728+_3.77**</td>
<td>4.04+_9.21**</td>
<td>4.67+_9.57*</td>
<td>2.51+_8.55**</td>
<td>-0.04+_5.75</td>
</tr>
</tbody>
</table>

Where; *=P<0.05 and **=P<0.01
Table (10): Estimation of genetic parameters for earliness, yield and its attributes traits in 2015 season

<table>
<thead>
<tr>
<th>Characters</th>
<th>Days to 50% flowering</th>
<th>Physiological maturity</th>
<th>Plant height</th>
<th>First capsule height</th>
<th>Fruit zone length</th>
<th>Number of branches</th>
<th>Number of capsules/plant</th>
<th>1000-seed weight</th>
<th>Seed yield/plant</th>
<th>Seed yield/plot</th>
<th>Seed oil content</th>
</tr>
</thead>
<tbody>
<tr>
<td>((H_1/D)^{0.5})</td>
<td>1.27</td>
<td>0.80</td>
<td>2.93</td>
<td>1.12</td>
<td>1.39</td>
<td>1.94</td>
<td>2.84</td>
<td>1.45</td>
<td>1.16</td>
<td>1.18</td>
<td>1.28</td>
</tr>
<tr>
<td>(H_2/4H_1)</td>
<td>0.22</td>
<td>0.24</td>
<td>0.24</td>
<td>0.19</td>
<td>0.19</td>
<td>0.22</td>
<td>0.21</td>
<td>0.20</td>
<td>0.18</td>
<td>-0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>KD/KR</td>
<td>0.79</td>
<td>0.69</td>
<td>1.26</td>
<td>2.51</td>
<td>2.52</td>
<td>1.97</td>
<td>1.95</td>
<td>2.26</td>
<td>2.61</td>
<td>2.57</td>
<td>2.05</td>
</tr>
<tr>
<td>R</td>
<td>0.86</td>
<td>-0.68</td>
<td>0.66</td>
<td>0.91</td>
<td>-0.33</td>
<td>0.88</td>
<td>0.05</td>
<td>0.41</td>
<td>0.09</td>
<td>-0.05</td>
<td>-0.87</td>
</tr>
<tr>
<td>(h^2/H_2)</td>
<td>0.94</td>
<td>0.74</td>
<td>1.72</td>
<td>0.11</td>
<td>0.88</td>
<td>1.30</td>
<td>0.67</td>
<td>0.10</td>
<td>0.52</td>
<td>0.65</td>
<td>-0.001</td>
</tr>
<tr>
<td>(h^2(a.s))</td>
<td>0.62</td>
<td>0.77</td>
<td>0.17</td>
<td>0.38</td>
<td>0.28</td>
<td>0.04</td>
<td>0.09</td>
<td>0.28</td>
<td>0.40</td>
<td>0.39</td>
<td>0.48</td>
</tr>
<tr>
<td>(h^2(b.s))</td>
<td>0.91</td>
<td>0.95</td>
<td>0.98</td>
<td>0.86</td>
<td>0.98</td>
<td>0.74</td>
<td>1.00</td>
<td>0.95</td>
<td>0.98</td>
<td>0.99</td>
<td>0.99</td>
</tr>
</tbody>
</table>

The average degree of dominance over all loci Table (10), as estimated by \((H_1/D)^{0.5}\) ratio was found to be more than unity for all traits except days to physiological maturity indicating the role of over dominance gene effects in the inheritance of this traits, for which less than unity indicating the presence of partial dominance in the control of the traits. Correlation of \((W_r+V_r)\) and \(Y_r\) as seen in Table (10), which was lower than zero showed that all studied traits except No. of branches and thousand seed weight, indicating the dominance genes had considerable effects on the these traits.

The \(h^2/H_2\) values Table (10) were less than unity for all studied traits except plant height implied to be governed by one gene. Estimates of broad sense heritability, for all traits in Table (10) were very high and varied from 1.00 to 0.74. On the other hand, narrow sense heritability was found to be low for all studied traits except days to 50% flowering, days to physiological maturity with values ranging from 0.04 to 0.77, indicating that selection should be delayed to late segregating generations. However, three traits had relatively high narrow sense heritability such as days to 50% flowering (0.62), days to physiological maturity (0.77) as well as first capsule height (0.38) and seed oil content (0.48) suggesting that selection would be effective for improving these traits.

REFERENCES


