Genetic Variability and Correlation Analysis of Ethiopian Linseed (\textit{Linum usitatissimum} L.) Accessions

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Abstract This study was executed in 2012/13 cropping season to determine variation of 202 accessions and correlation coefficients of some agronomic characters. The experiment was carried using augmented design with no replication. Accessions showed variation for days to flowering ranged between 77 and 135 days with a mean value of 99.65 and coefficient of variation 13%. Accessions such as acce # 10 077, 10 078, 1 0079, 10 084, 10 086, 10 087, 13 578, 13 598, 13 620 and 13 649 showed earliness, which ranged from 170-172 days to mature, while accessions such as acce # 212 854, 212 857, 215 716, 213 106, 10 104, and 10 105 took 180-182 days to mature. A range of 14.0 to 38.8 was recorded for number of capsule per plant with a mean value of 23.12 and coefficient of variation 19%. Accessions such as acce # 230 822, 10 070, 10 105, 10 086, 10 069, 10 079, 10 052 and 219 969 had number of capsule ranged from 32 –41. A significant amount of variation was also observed for seed yield, which was between 104 kg/ha and 1982 kg/ha with a mean value of 984.37 kg/ha and coefficient of variation 39%. Accessions such as acce # 10 067, 10 061, 10 084, 10 069, 13 755, 10 070, 10 054, 10 068, 241 826, 10 064 and 10 150 were high yielding, which varied between 1 592 kg/ha and 1 990 kg/ha. Correlation coefficient analysis indicated that seed yield had significant positive association with plant height (0.215 9), number of secondary branches (0.204 8), and number of capsule (0.384 6), while it recorded significant negative correlation with days to maturity (-0.142 6) and number of primary branches (-0.298 2). This study has also suggested that number of capsule per plant was found to be the most important yield component for the improvement of seed yield of linseed.

Keywords Accessions; Correlation coefficients; Linseed; Variation; Yield; Yield component

Background

Linseed (\textit{Linum usitatissimum} L.; 2n=30) is one of the most important oil crops in the highlands of Ethiopia. It is cultivated for seed production, which is used for extracting edible oil. Ethiopia is the seventh world linseed producing countries after Canada, Russia, China, Kazakhstan, United States and India (FAO, 2012). According to CSA (2014) data, it covered an area of 82, 325.78 ha of cultivated land, and produced 83, 130.5 tones with productivity of 1.0 t ha-1. It is commonly grown on marginal lands with less or no input (Teklewolde et al., 1992). Increasing seed yield of linseed is the main breeding objective along with others such as breeding for quality, disease resistance, frost resistance etc.

Genetic variation is a prerequisite for any crop breeding. Studies on genetic variation have been carried out by several researchers (Fu et al., 2002; Adugna and Labuschanagne, 2004; Tadesse et al., 2009; Kandil et al., 2012). As seed yield is an intricate character, studying the association of characters is of paramount importance in order to improve the seed yield through indirect selection of yield related characters. Several researches have been executed on characters association (Kapoor and Chawla, 1983; Mirza et al., 1996; Adugna and Labuschanagne, 2003; Saeid et al., 2003; Copur et al., 2006). This study was undertaken to determine the genetic variation among 202 linseed accessions and determine the association of characters.

1 Results and Discussion

1.1 Days to flowering

Days to flowering had variation ranged from 77.00 to 135.00 with a mean value of 99.65 and coefficient of variation 19%. Accessions such as acce # 230
variation 13% (Table 1). The frequency distribution ranged from 77 to 137 days (Figure 1). Early flowering accessions (77-80 days) were acce # 10 143, 125 162, 125 163, 235 165, 235 166, 241 828, 242 588, and 242 596, while accessions such as acce # 10 084, 10 086, 10 087, 13 712, 13 755, and 13 756 were late to flower, which had recorded 124-135 days to mature.

1.2 Days to maturity
This character varied between 170 and 180 days with a mean value of 175.5 and coefficient of variation 1% (Table 1). The frequency distribution showed that the accessions ranged between 170 and 182 days in maturity (Figure 2). Acce # 10 077, 10 078, 10 079, 10 084, 10 086, 10 087, 13 578, 13 598, 13 620, and 13 649 were the earliest to mature, which took 170-172 days. On the other hand, acce # 212 854, 212 857, 215 716, 10 103, 10 104, and 10 105 were late to mature with 180-182 days to maturity.

1.3 Plant height
Significant variability was observed for plant height, which is ranged from 17.7 cm to 97 cm with a mean value of 53.27 cm and coefficient of variation 22% (Table 1). Majority of the accessions were between 41.7 cm and 57.7 cm (Figure 3). Accessions such as acce # 234 009 (17.7 cm), 234 008 (19.4 cm), 234 010 (21.1 cm), and 234005 (24.5) were the shortest in height, where as acce # 13 507 (84 cm), 207786 (88.5) and 13682 (97 cm) were the tallest accessions.

Table 1 Basic statistics of some agronomic characters of 202 linseed accessions

<table>
<thead>
<tr>
<th>Characters</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Variance</th>
<th>SD</th>
<th>CV (%)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF</td>
<td>99.65</td>
<td>77.00</td>
<td>135.00</td>
<td>160.17</td>
<td>12.69</td>
<td>13.00</td>
<td>0.89</td>
</tr>
<tr>
<td>DM</td>
<td>175.56</td>
<td>170.00</td>
<td>180.00</td>
<td>4.22</td>
<td>2.06</td>
<td>1.00</td>
<td>0.14</td>
</tr>
<tr>
<td>PH</td>
<td>53.27</td>
<td>17.70</td>
<td>97.00</td>
<td>140.53</td>
<td>11.88</td>
<td>22.00</td>
<td>0.84</td>
</tr>
<tr>
<td>NPB</td>
<td>4.25</td>
<td>3.00</td>
<td>6.70</td>
<td>0.49</td>
<td>0.71</td>
<td>16.00</td>
<td>0.05</td>
</tr>
<tr>
<td>NSB</td>
<td>6.61</td>
<td>3.40</td>
<td>9.50</td>
<td>1.41</td>
<td>1.19</td>
<td>18.00</td>
<td>0.08</td>
</tr>
<tr>
<td>NC</td>
<td>23.12</td>
<td>14.00</td>
<td>38.80</td>
<td>20.17</td>
<td>4.50</td>
<td>19.00</td>
<td>0.32</td>
</tr>
<tr>
<td>SY</td>
<td>984.37</td>
<td>104.00</td>
<td>1982.00</td>
<td>14672560.00</td>
<td>384.00</td>
<td>39.00</td>
<td>27.02</td>
</tr>
</tbody>
</table>

Note: DF: 50% days to flowering; DM: Days to maturity; PH: Plant height; NPB: Number of primary branches; NSB: Number of secondary branches; NC: Number of capsules; SY: Seed yield; SD: Standard deviation; CV: Coefficient of variation; SE: Standard error

![Figure 1](image1.png)  ![Figure 2](image2.png)

Figure 1 Frequency distribution of days to flowering for 202 linseed accessions
Figure 2 Frequency distribution of days to maturity for 202 linseed accessions
1.4 Number of primary branches
The magnitude of variation for this character was between 3 and 6.7 with a mean value of 4.25 and coefficient of variation 16% (Table 1). 86.1% of the accessions had 3-5 primary branches per plant (Figure 4).

1.5 Number of secondary branches
The variability of this character ranged from 3.4 to 9.5 with a mean value of 6.61 and coefficient of variation 18% (Table 1). 78.7% of the accessions had 5.4-8.4 secondary branches per plant (Figure 5).

1.6 Number of capsules
A range of 14.0 to 38.8 was recorded for this character with a mean value of 23.12 and coefficient of variation 19% (Figure 6). 49% of the accessions recorded above the average (Figure 6). Eight accessions such as ace # 230 822, 10 070, 10 105, 10 086, 10 069, 10 079, 10 052, and 219 969 had number of capsule ranged from 32-41. Variation in number of capsules was also reported by Wakjira (2011).

1.7 Seed yield
Significant variation was observed for seed yield, which ranged from 104 kg/ha to 1 982 kg/ha with a mean value
of 984.37 kg/ha and coefficient of variation 39% (Table 1). 48.5% of the accessions showed above the mean value (Figure 7). Accessions such as acce #1 0067, 10 061, 10 084, 10 069, 13 755, 10 070, 10 054, 10 068, 241 826, 10 064, and 10 150 were high yielding, which ranged between 1 592 kg/ha to 1 990 kg/ha. Similarly, Wakjira (2011) reported high variation in yield per plant. Significant variation in seed yield was also reported by Ottai et al. (2012).

1.8 Correlation analysis
Correlation coefficient analysis is presented (Table 2). This analysis depicted that seed yield had highly significant positive association with plant height (0.215 9), number of secondary branches (0.204 8), and number of capsule per plant (0.384 6), while it recorded significant negative relationship with days to maturity (-0.142 6) and number of primary branches (-0.298 2). Similar results were recorded on days to maturity, number of secondary branches, and number of capsule, but the opposite for number of primary branches (Savita, 2006). Number of capsule had also significant positive association with seed yield (Popescu et al. 1999; Belete and Wolde Yohanes, 2013). Days to maturity showed significant positive correlation with number of primary branches (0.142 9). Number of secondary branches recorded significant positive association with plant height (0.147 8), number of primary branches (0.203 7), and number of capsule per plant (0.515 3).

![Figure 7 Frequency distribution of seed yield (kg/ha) for 202 linseed accessions](image)

Table 2 Correlation coefficients among agronomic characters measured in 202 accessions of linseed

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>DM</th>
<th>PH</th>
<th>NPB</th>
<th>NSB</th>
<th>NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>-0.1477*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td>0.3999**</td>
<td>-0.1324</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPB</td>
<td>0.1675*</td>
<td>0.1429*</td>
<td>-0.0681</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSB</td>
<td>0.1690*</td>
<td>0.0189</td>
<td>0.1478*</td>
<td>0.2037**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NC</td>
<td>-0.0543</td>
<td>-0.0787</td>
<td>0.1307</td>
<td>0.0175</td>
<td>0.5153**</td>
<td></td>
</tr>
<tr>
<td>SY</td>
<td>0.0020</td>
<td>-0.1426*</td>
<td>0.2159**</td>
<td>-0.2982**</td>
<td>0.2048**</td>
<td>0.3846**</td>
</tr>
</tbody>
</table>

Note: *, ** significant at p≤0.05 and p≤0.01 level, respectively; DF: 50 % days to flowering; DM: Days to maturity; PH: Plant height; NPB: Number of primary branches; NSB: Number of secondary branches; NC: Number of capsules; SY: Seed yield

2 Materials and Methods
The present study was carried out at Holetta Agricultural Research Center in 2012 cropping season. The experiment was laid out using augmented design with no replication, and 202 accessions including checks were grown in two rows of 3 m length and 30 cm between rows. All the management practices were followed as per the
recommendation. Ten plants from each accession were selected to record data on days to flowering, days to maturity, plant height (cm), number of primary branches, number of secondary branches and number of capsule per plant. Seed yield (kg/ha) was recorded on plot basis. Descriptive statistics and Pearson correlation coefficients were determined using AGROBASETM software (Agronomix Software Inc., Canada).

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