Yield evaluation and character association of linseed (Linum usitatissimum L.) genotypes in moisture stress areas of South Tigray, Ethiopia

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Linseed (Linum usitatissimum L.) is one of the most important highland oil crops of southern Tigray, Ethiopia and it is considered as the least expensive source for oil related home consumptions. The 12 genotypes of linseed including two standard checks were evaluated in the highland and moisture stress area of Southern Tigray under rain fed condition with the objective of evaluating yield and yield components as well as their association. Observations were recorded for different characters, viz., days to maturity, plant height, and number of capsules per plant, number of seeds per capsule, 1000-seed weight and seed yield. Highly statistical significant (P < 0.01) differences were found among the genotypes for days to maturity, plant height and seed size. The standard checks (Bekoji and Kassa -2) were matured late (122 days after emergence) in the growing area as compared with the other genotypes. These genotypes had long plant height (89.4 and 87.3 cm, respectively) and they showed higher significant difference. Genotypes 20-Marc, 8-Marc, 4-Marc, 11-Marc and 31-Marc were matured with in 103, 104, and 105 days in that order and they were earlier as compared to others. Mean seed yield had positive correlation with all yield components except 1000 seed weight. Significantly higher positive significant correlation was observed among days to maturity and plant height (r = 0.73). Plant height also showed positively and significantly correlation with seed weight (0.54). Therefore, strong and positive association between seed yield and some of yield related traits provide the opportunity to improve seed yield and other desirable traits of linseed.

Key words: Correlation, genotype (entry or variety), linseed, yield component.

INTRODUCTION

Linseed (2n = 30) is an important oilseed and fiber crop which belongs to the family Linaceae (as cited by Mulusew et al. (2013). It is believed that this crop species may have originated from Linum angustifolium Huds. (2n = 30) native to the Mediterranean region (Cooke, 1903; Legesse, 2010). Linseed is an annual field crop that is largely grown in temperate areas of the world (Mansby et al., 2000) and cool tropics including highland areas of...
Ethiopia with its altitude ranging from 2500 m. above sea level and more. It is the second most important oil crop in the highlands of Ethiopia in terms of area coverage and production (Adefris et al., 1992; Adugna, 2000). Linseed requires cool temperatures ranging from 10 to 30°C although the crop grows best within 21 and 22°C during its growing period to produce good yields. According to Adugna (2007), Ethiopia is considered to be the secondary center of diversity, and now the 5th major producer of linseed in the world after Canada, China, United States and India. The crop performs best in altitudes ranging from 2200 to 2800 meters above sea level (Reta and Nigussie, 2017). The wide range of agroclimatic conditions in Ethiopia may have contributed to its wider diversification for this oil crop. In the 2015/2016 cropping season, 85,415.67 ha of land was covered in Ethiopia with linseed and the production was estimated to be 885,511.44 quintals (MoANR, 2016).

In Ethiopia, linseed has been cultivated primarily for seed and oil purposes. Linseed oil content is mainly in the range of 35 - 44% with drying oil properties (Tesfaye et al., 2016). The seed is commonly roasted, ground and mixed with spices and some water to be served along with local breads. It also consumed in soups, soft drinks and with porridge or cooked potatoes. Its industrial use is higher than all other oil crops. It has traditionally been used for food and as a cash crop since ancient times. Its seeds are usually roasted, ground, mixed with spices and water, and served with various local consumptions. Linseed oil has been used for edible purpose in the past years.

The ground seed is of great value for a number of purposes including gastric pain and the extracted mucilage is used in cosmetic and pharmaceutical industries (Hiruy and Nigussie, 1988). The oil is also used as a raw material for a number of industrial products, such as drying agents, paintings and varnishes, soap manufacture, printing inks etc., whereby it lends itself as an export commodity, thus, contributing a lot towards building the national economy (Reta and Nigussie, 2017).

The highland areas of Southern Tigray are one of the potential areas for the production of highland oil crops in Ethiopia, and linseed is the only main oil crop grown in the area. Despite its potential and profitability, the crop has been traditionally grown on marginal lands using local variety. No improved linseed variety has been grown in the area and the locally cultivated accessions (land races) are not yet collected and tested for their yield potential and other yield components. On the contrary, there is a sever shortage of edible oil in the country (Ethiopia) in general and the Tigray region in particular. Hence, the objective of this study is to evaluate the overall performances of the locally collected accessions (landraces) and released linseed varieties to increase the production and productivity of the crop and contributes to minimize the edible oil shortage in the country as well as to exploit the linseed production capacity for domestic uses and export purposes.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted in the field of farmers' training center found at Mekhan kebelle of Endamekhi district, Southern Tigray, Ethiopia during the main cropping season of 2019. Mekhan FTC is located at the distance of 660 km from Addis Ababa (the capital city of Ethiopia) and 125 south of Mekelle. This center is also found at about 12°33'21" N latitude, 39°25'28" E longitude and at an altitude of about 2480 m above sea level (Amanuel et al., 2015). The area is characterized by moisture stress agro-ecology but bimodal rainfall pattern. According to Amanuel et al. (2015), the minimum and maximum annual temperature of the study area is 8-25°C, respectively and the annual rainfall distribution ranges from 600 - 800 mm.

Experimental materials

Twelve entries (genotypes) of linseed including two standard checks were collected from Tigray region and evaluated in the study area. The experiment was laid out in a randomized complete block design with three replications. The plot size was 1.2 × 5 m with spacing of 20 cm between rows and drilling method of sowing. The four central rows were used for data collection and all agronomic practices were done as per the recommendations.

Collected data and analysis of variance

The yield and yield component parameters were collected that include days to physiological maturity, plant height, number of capsules per plant, number of seeds per capsule, 1000 seeds weight and seed yield. The collected data were analyzed using the standard procedure applicable to randomized complete block design as suggested by Gomez and Gomez (1984) using GenStat version 16 software programs and least significance difference was used for the mean comparison both at 1 and 5% probability level.

RESULTS AND DISCUSSION

Analysis of variance and estimation of variance components

The mean days to maturity, 1000 seed weight, plant height, number of capsules per plant, number of seeds per capsule and seed yield were analyzed. A higher significant (P < 0.01) difference was observed on the genotypes for days to maturity, plant height and thousand seed weight (Table 1). This finding is in consistent with Tesfaye et al. (2016). Non -significant (P > 0.05) differences were observed among the genotypes for seed yield, number of capsules per plant and number of seed per capsule.

The standard checks (Bekoji and Kassa -2) matured late (122 days after emergence) in the growing area as compared with the other genotypes. However, genotypes 20-Marc, 8-Marc, 4-Marc, 11-Marc and 31-Marc matured
Table 1. Mean Seed yield and other agronomic characters of linseed genotypes.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>DM</th>
<th>PHT (cm)</th>
<th>NCPP</th>
<th>NSPC</th>
<th>TSW (g)</th>
<th>SY (kg/ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-Marc</td>
<td>103</td>
<td>62.0</td>
<td>32</td>
<td>7.9</td>
<td>4.933</td>
<td>1980</td>
</tr>
<tr>
<td>8-Marc</td>
<td>104</td>
<td>61.5</td>
<td>25</td>
<td>7.8</td>
<td>4.667</td>
<td>1836</td>
</tr>
<tr>
<td>4-Marc</td>
<td>105</td>
<td>64.3</td>
<td>31</td>
<td>9.0</td>
<td>5.200</td>
<td>1910</td>
</tr>
<tr>
<td>11-Marc</td>
<td>105</td>
<td>61.3</td>
<td>28</td>
<td>8.3</td>
<td>5.267</td>
<td>1698</td>
</tr>
<tr>
<td>31-Marc</td>
<td>105</td>
<td>60.9</td>
<td>27</td>
<td>8.1</td>
<td>4.933</td>
<td>1865</td>
</tr>
<tr>
<td>19-Marc</td>
<td>108</td>
<td>64.1</td>
<td>33</td>
<td>8.1</td>
<td>4.867</td>
<td>1950</td>
</tr>
<tr>
<td>234008t</td>
<td>112</td>
<td>68.1</td>
<td>23</td>
<td>8.5</td>
<td>4.400</td>
<td>1945</td>
</tr>
<tr>
<td>22-Marc</td>
<td>113</td>
<td>61.6</td>
<td>25</td>
<td>8.0</td>
<td>4.867</td>
<td>1997</td>
</tr>
<tr>
<td>28-32 Marc</td>
<td>115</td>
<td>68.0</td>
<td>23</td>
<td>8.5</td>
<td>4.533</td>
<td>2194</td>
</tr>
<tr>
<td>237001</td>
<td>116</td>
<td>65.5</td>
<td>30</td>
<td>8.3</td>
<td>4.400</td>
<td>2167</td>
</tr>
<tr>
<td>Bekoji</td>
<td>122</td>
<td>89.4</td>
<td>31</td>
<td>7.5</td>
<td>5.667</td>
<td>2182</td>
</tr>
<tr>
<td>Kassa-2</td>
<td>122</td>
<td>87.3</td>
<td>25</td>
<td>7.7</td>
<td>5.733</td>
<td>1836</td>
</tr>
<tr>
<td>Mean</td>
<td>110.7</td>
<td>67.8</td>
<td>28</td>
<td>8.1</td>
<td>5.0</td>
<td>1963</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>4.316**</td>
<td>8.312**</td>
<td>NS</td>
<td>NS</td>
<td>0.542**</td>
<td>NS</td>
</tr>
<tr>
<td>CV (%)</td>
<td>2.3</td>
<td>7.2</td>
<td>21</td>
<td>6.9</td>
<td>6.5</td>
<td>14.8</td>
</tr>
</tbody>
</table>

NS = Non-significant difference, DM = Days to maturity, PHT = Plant height, NCPP = Number of capsules per plant, NSPC = Number of seeds per capsule, TSW = Thousand seed weight, SY = Seed yield.

Within 103, 104, and 105 days in that order and they were earlier in days to maturity. In similar manner, both the standard checks varieties had long plant height (89.4 and 87.3 cm) and they showed highest significant (P < 0.01) difference with the other genotypes (Table 1).

### Performance of seed yield and seed size of linseed genotypes

The seed yield has revealed that no significant (P > 0.05) variation was observed among the genotypes of linseed. However, numerically genotypes 28-32 Marc, Bekoji, and 237001 gave higher seed yield as 2194, 2182, 2167 kg ha⁻¹, respectively. The character tested previously in Ethiopia and other countries, the mean seed yield obtained in this research is higher and very appreciable even in most or all tested materials. For example in Ethiopia, lower seed yield is recorded in different research results conducted and displayed by various professionals (Tesfaye et al., 2016; Lirie et al., 2013; Abebe et al., 2010; Yared and Miteru, 2016). This could be related to the suitability of the agro-ecology of the area to these tested and higher yielder genotypes. Very high significant (P < 0.01) difference was observed among the tested linseed genotypes for seed size (Table 1). The Bekoji, Kassa-2, 11-Marc and 4-Marc gave highest and similar 1000 seed weight (5.733, 5.667, 5.267 and 5.201 g, respectively) and there was no significant difference among the genotypes. On the other hand, even though they showed similar p-value with some other genotypes, entry 237001 and 234008t scored lowest seed weight (4.400 g 1000⁻¹).

### Correlation of seed yield with other characters

Correlation coefficient estimates degree of association of different linseed yield and yield components among themselves. Based on this, the values of Pearson correlation coefficient revealed that days to maturity and plant height showed highly significant and positive correlation (0.73). This situation was observed in Bekoji and Kassa-2 genotypes which had long plant height as a result of late days to maturity. This result is in consonance with Yared and Miteru (2016) and Reddy et al. (2013). Mean plant height had significant positive correlation with number of capsules per plant. Similar findings were reported by Dashe et al. (2016), Naik and Satapathy (2002) and Savita (2006).

Even though there was no significant correlation of seed yield with days to maturity, number of capsules per plant, number of seeds per capsule and plant height, the relationship was positive (Table 2). Similar results were reported by Dash et al. (2016); Tesfaye et al. (2016) and Tadesse et al. (2009). Therefore, number of seeds per capsule (0.114), days to maturity (0.18) and plant height (0.19) showed a low positive direct effect on the seed yield genotypes (Ibrar et al., 2016).

On the other hand, seed yield has negative correlation with 1000 seed weight in very low amount (r = -0.0896). This result is in agreement with Yadav et al. (2017) and Dash et al. (2016). Thousand seed weight has significant and positive association (r = 0.5358) with plant height but non-significantly correlation with days to maturity and number of capsules per plant (r = 0.27 and 0.28, respectively). The 1000 seed weight correlates with number of seeds per capsule negatively (r = -0.33), that
is, a decrease was observed in seed weight with increasing number of seeds per capsule. Dash et al. (2016) and Mahto and Rahaman (1998) found negative correlation with number of seeds per capsule and 1000-seed weight. The mean number of capsules per plant had positive but non-significant difference correlation with plant height and 1000-seed weight. This is in consonance with the findings of Savita (2006). The number of seeds per capsule negatively correlates with most traits, that is, with days to maturity, number of capsules per plant, plant height, and seed size but only positively correlated with seed yield. Also Mahto and Rahaman (1998) and Naik and Satapathy (2002) had result similar with this result. The strong and positive association between seed yield and some of yield related traits provides the opportunity to improve seed yield and other desirable traits simultaneously. Linseed traits that did not have significant correlation with seed yield indicate that selection for increased levels of these traits may not bring significant change in seed yield.

**Conclusion**

The days to maturity is an important parameter for the study areas as the testing location is characterized by moisture stress condition. Genotypes 20-Marc and 8-Marc showed earlier days to maturity with their reasonable seed yield and breeders should consider not only to seed yield but also to earlier physiological maturity of linseed entries selection. The yield components which include number of capsules per plant, number of seeds per capsule, plant height and seed size are the important selection parameters to improve linseed yield. Almost all of the above traits correlate positively with seed yield because these parameters had positive direct effect on the seed yield as their correlation values were in the positive direction.

**CONFLICT OF INTERESTS**

The author has not declared any conflict of interests.

**Table 2. Correlation coefficients among the traits measured from twelve linseed genotypes.**

<table>
<thead>
<tr>
<th>Trait</th>
<th>DM</th>
<th>PHT</th>
<th>NCPP</th>
<th>NSPC</th>
<th>TSW</th>
<th>SY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHT</td>
<td>0.7283</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCPP</td>
<td>-0.0764</td>
<td>0.0125</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSPC</td>
<td>-0.1394</td>
<td>-0.2024</td>
<td>-0.0308</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSW</td>
<td>0.2664</td>
<td>0.5358</td>
<td>0.2762</td>
<td>-0.3329</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>SY</td>
<td>0.2233</td>
<td>0.2593</td>
<td>0.2278</td>
<td>0.0181</td>
<td>-0.0847</td>
<td>-</td>
</tr>
</tbody>
</table>

DM = Days to maturity, PHT = Plant height, NCPP = Number of capsules per plant, NSPC = Number of seeds per capsule, TSW = Thousand seed weight, SY = Seed yield.

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**REFERENCES**


