Evaluation of 25 Safflower Genotypes for Seed and Oil Yields Under Arid Environment in Upper Egypt

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ABSTRACT
Seed and oil yields, their components and the relationships among yield and related traits were measured in 25 safflower (Carthamus tinctorius L.) genotypes, under arid conditions. The studies were conducted in sandy-loam soil at the experimental farm of Faculty of Agriculture, South Valley University, Qena, Egypt, during two seasons, 2009-10 and 2010-11. The trials were laid out in randomized complete block design with three replications. Significant differences were observed at 1% probability level in plant height, number of branches and capitula per plant, 1000-seed weight, weight of seed per plant, oil content and seed and oil yields among the genotypes. The Line-1682 produced the highest plant height (199.7 cm), number of branches plant⁻¹ (9.000), number of capitula plant⁻¹ (25.69), weight of seed plant⁻¹ (39.46 g), seed yield (2846 kg ha⁻¹), seed oil content (36.50%) and oil yield (1039 kg ha⁻¹), while Line-1687 produced the highest 1000-seed weight (49.13 g). The lowest values for above mentioned traits were obtained from Line-1679 except the lowest 1000-seed weight and oil content were resulted from Line-1671 and Line-1638, respectively. Oil yield expressed firm correlation with, plant height (r = 0.566**), branches per plant (r = 0.591**), capitula per plant (r = 0.628**), seed weight per plant (r = 0.863**), seed yield (r = 0.990**) and seed oil content (r = 0.711**).

Key words: Safflower, genotypes, oil content, oil yield, correlation, regression

INTRODUCTION
Safflower (Carthamus tinctorius L.) belongs to the family Compositae or Asteraceae. The crop was initially grown to produce dyes for food and fabric and for medicinal use, but is currently cultivated for edible oil and birdseed (McPherson et al., 2004). For human nutrition, safflower oil has a nutritional value that similar to olive oil; moreover, the high oleic type is very suitable for hypo-cholesterol diets, for frying and in the preparation of frozen food (Ekin, 2005). Safflower is a temperate zone plant grown in arid and semiarid regions of world. This plant is considered as a drought tolerant crop which is capable of obtaining moisture from levels not available to the majority of crops (Weiss, 2000). Development of oil seeds cultivation has an important role to provide the requisite edible oils for human beings (Eslam, 2004). The germplasm resources of safflower have so far been characterized entirely on the basis of morphological traits, agronomic characters, biotic and (or) abiotic stress and (or) biochemical characters (Han and Li, 1992; Aslam and Hazara, 1993; Fernandez et al., 1993). In a study of 199 safflower genotypes collected from 37 different countries, Deharo et al. (1997) found that the oil percent varied by genotype and environmental conditions. Number of capitula, seed weight and seed oil content varies considerably in the safflower population (Parameshwarappa and Meghannavar, 2001). Safflower genotypes varied significantly in seed yield and its attributes, oil percent and oil yield per unit area (El-Gayar et al., 1990; Mundel et al., 1999; Omidi Tabrizi, 2006; Camas et al., 2007). Safflower seed yield is affected cultivar was found by several workers (Alizadeh and Carapetian, 2006; Mahasi et al., 2003).
Evaluation of relationships among traits in safflower indicated that positive and significant relationships among grain yield with plant height, number of head per plant, 100-seed weight, seed oil content and oil yield (Tunceturk and Çiftci, 2004). In a research with 25 accessions of Carthamus tinctorius Pascual-Villalobos and Alburquerque (1996) found positive correlation coefficients between seed yield and number of capitula/plant, number of branches/plant and plant height. Negative correlations were found between 1000-seed weight and number of seeds/capitulum in their research. A positive correlation was found among grain yield and, number of capitula per plant (Bagavan and Ravikumar, 2011), seed weight and plant height (Johnson et al., 2001). Also, positive correlations among seed oil and seed and oil yields were obtained (Eslam et al., 2010).

In recent years, there has been a proliferation of safflower cultivars and many excellent genotypes with superior properties are now available. This demonstrates a need for additional research examining the agronomic performances of newly released safflower genotypes in diverse regions. This study was initiated to evaluate the agronomic performance of new safflower genotypes under arid environment in Upper Egypt.

MATERIALS AND METHODS

A field study of 25 safflower genotypes was conducted at the experimental farm of Faculty of Agriculture, South Valley University (latitude 26°10’ N, longitude 32°43’ E, Altitude 70 m above sea level) in Qena, Egypt, during two seasons, 2009-10 and 2010-11. The weather is very hot and dry from May to October where temperatures can reach up to 40 °C. On the other hand, the weather is usually warm during winter months and rainfall is rare. The soil of the experimental site is sandy-loam throughout its profile (74.8% sand, 16.2% silt and 9.3% clay). Its pH value of 7.89, EC is 1.98 dS m⁻¹, organic matter content is 0.44%, total N 0.35% and available P and K of 8.55, 186 ppm, respectively. The trials were laid out in randomized complete block design with three replications. Experimental unit measured 3.6 m in width and 5 m in length.

Genotypes seeds were sown by hand (30 kg ha⁻¹) on November 7th and 10th in the first and second seasons, respectively as the usual dry method of sowing on one side of ridges (60x15 cm). The preceding crop was sunflower in both seasons. The N, P₂O₅ and K₂O fertilizers were applied at 140, 55 and 60 kg ha⁻¹, respectively. The other agronomic practices were kept normal and uniform for all plots. The origin of genotypes was shown in Table 1.

Hand harvesting was performed about 150 days after sowing. At harvest time, ten guarded plants were taken at random from each plot to measure plant height, number of branches and capitula per plant and weight of seeds per plant. Also, 1000-seed weight was determined for each experimental unit. Seed yield was estimated on plot basis. Seed oil content was determined using Soxhlet apparatus, according to AOAC (1990). Oil yield was calculated by multiplying seed yield by seed oil content (%).

Data were subjected to analysis of variance (ANOVA) using MSTAT-C software. Homogeneity of error variance was tested before combining data over years. The least significant differences (LSD at p<0.05 level) used to compare the genotypes means.

RESULTS AND DISCUSSION

The results of the combined analysis of variance, after homogeneity test for error variances, are summarized in Table 2. F-test of different sources of variation revealed that there were no significant differences of the year or genotype x year interaction effects, while genotypes were significant (p<0.01) on all studied traits.
Yield components performance: The plant height ranged from 151.5 cm (Line-1679) to 199.7 cm (Line-1682) and Line-1678 (186.6 cm) ranked second in plant height (Table 3). Plant height is a trait under genetic control but its manifestation depends on prevailing environmental factors. These results concur with the results of others (El-Gayar et al., 1990; Pascual-Villalobos and Alburquerque, 1996). Kourtoubas et al. (2004) found that safflower genotypes differed in plant height. Overall, higher plant heights in the current study were probably caused by low altitude. This agrees with the study of Kofidis et al. (2003), who found that oregano plants grown at high altitude were shorter than those grown at low altitude.

In average of seasons, the highest branches (9.000) and capitula (25.69) number per plant were obtained from the genotype Line-1682. The lowest values for branches (5.333) and capitula (12.84) number were measured in Line-1679 (Table 3). The results are supported by the findings...
of Narkhide and Patil (1990) and Mane et al. (1990), may have reported varietal differences in their respective studies.

The 1000-seed weight maximum (49.13 g) was recorded from Line-1687, followed by Line-1697 (48.75 g) and Line-1675 (47.07 g). Line-1671 produced the minimum (30.17 g) thousand seed weight. Variation in 1000-seed weight between genotypes of safflower has reported by Narkhide and Patil (1990), Mane et al. (1990) and Mahasi et al. (2005).

Line-1682 had higher seed weight per plant (39.46 g) relative to others, whereas lower seed weight per plant (6.09 g) was obtained from genotype Line-1679. A similar result was found in a previous study in Kenya evaluating 36 exotic safflower accessions for agro-morphological characters such as yield per plant (Mahasi et al., 2005).

**Yield performance:** Data in Table 3 showed that Line-1682 gave the highest value of seed yield (2846 kg ha⁻¹). Seed yield of Line-1679 (512 kg ha⁻¹) was the lowest as compared with the other genotypes under study. In general, the superiority of Line-1682 on others genotypes in theses characteristics may be attributed inherently to the greater ability of such genotype in synthesizing more assimilates that partitioned to the final economical yields of safflower plants and the consequent dry matter accumulation. Also, this genotype gave the more branches and capitula per plant and seed per plant compared with others genotypes (Table 3). The results are supported by
the findings of El-Gayar et al. (1990), Narkhede and Patil (1990), Mundel et al. (1999), Mahasi et al. (2005), Omidi Tabrizi (2006), Camas et al. (2007), El-Lattief et al. (2009) and Eslam et al. (2010), may have reported varietal differences in their, respective studies.

Seed oil concentration and oil yield: Line-1682 produced the highest oil content of 36.50%, followed by Line-1690 (36.36%) without differences significant between them. Line-1688 produced the minimum oil content of 26.36%, followed by Line-143 (27.12%), Line-1679 (27.40%) and Line-153 (27.95%) without any differences significant among them. Similar results were reported by Narkhede and Patil (1990), Camas et al. (2007) and El-Lattief et al. (2009).

The effect of safflower genotypes on the oil yield was significant at 1% level (Table 2). Means in Table 3 indicates that superiority of oil yield was achieved by genotype Line-1682 (1039 kg ha\(^{-1}\)). Like seed yield, oil yield of Line-1679 (141 kg ha\(^{-1}\)) was the lowest as compared with the other genotypes. The superiority of genotype Line-1682 in oil yields is evident as it also caused highly significant values for seed yield ha\(^{-1}\) and seed oil concentration (Table 3). These results are agreement with Camas et al. (2007) and El-Lattief et al. (2009).

Correlation and regression analyses: Correlation coefficients among the studied traits are shown in Table 4. There were positive and significant correlations between seed yield and plant height (\(r = 0.551**\)), branches per plant (\(r = 0.581**\)), capitula per plant (\(r = 0.620**\)), 1000-seed weight (\(r = 0.175^*\)), seed weight per plant (\(r = 0.837**\)), seed oil content (\(r = 0.643**\)). Also, oil yield was positively and significantly correlated with, plant height (\(r = 0.666**\)), branches per plant (\(r = 0.591**\)), capitula per plant (\(r = 0.625**\)), 1000-seed weight (\(r = 0.172^*\)), seed weight per plant (\(r = 0.863**\)), seed yield (\(r = 0.990**\)) and seed oil content (\(r = 0.711**\)). It is quotable, the reported results by Omidi Tabrizi (2008), Bagavan and Ravikumar (2011), Johnson et al. (2001) and Eslam et al. (2010) have supported the present results. These results showed that any positive increase in such characters will suffice the boost in seed and oil yields.

<table>
<thead>
<tr>
<th>Traits</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant height</td>
<td>-</td>
<td>0.486**</td>
<td>0.454**</td>
<td>0.156**</td>
<td>0.628**</td>
<td>0.551**</td>
<td>0.480**</td>
<td>0.566**</td>
</tr>
<tr>
<td>Branches per plant</td>
<td>-</td>
<td>0.955**</td>
<td>-0.012**</td>
<td>0.614**</td>
<td>0.581**</td>
<td>0.432**</td>
<td>0.561**</td>
<td></td>
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<tr>
<td>Capitula per plant</td>
<td>-</td>
<td>-0.014**</td>
<td>0.629**</td>
<td>0.620**</td>
<td>0.441**</td>
<td>0.625**</td>
<td></td>
<td></td>
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<tr>
<td>1000-seed weight</td>
<td>-</td>
<td>0.147**</td>
<td>0.176**</td>
<td>0.119**</td>
<td>0.172**</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Seed weight per plant</td>
<td>-</td>
<td>0.837**</td>
<td>0.673**</td>
<td>0.863**</td>
<td></td>
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<tr>
<td>Seed yield per ha</td>
<td>-</td>
<td>0.645**</td>
<td>0.990**</td>
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<tr>
<td>Seed oil content</td>
<td>-</td>
<td>0.711**</td>
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</table>

* and ** Significant at \(p<0.05\) and \(p<0.01\), respectively ns: Non-significant \(p>0.05\)

Seed yield increased linearly with, plant height \(R^2 = 30.3\%**\), branches per plant \(R^2 = 33.8\%**\), capitula per plant \(R^2 = 38.4\%**\), 1000-seed weight \(R^2 = 3.0\%\), seed weight per plant \(R^2 = 70.0\%**\), seed oil content \(R^2 = 41.3\%**\), Table 5. Also, oil yield increased linearly with, plant height \(R^2 = 32.1\%**\), branches per plant \(R^2 = 34.9\%**\), capitula per plant \(R^2 = 39.0\%**\), 1000-seed weight \(R^2 = 3.0\%\), seed weight per plant \(R^2 = 74.5\%**\), seed oil content \(R^2 = 50.5\%**\). Meanwhile, a positive quadratic response in oil yield occurred as the seed yield was increased \(R^2 = 98.1\%**\), Table 5.

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Table 5: Regression equation and relative contribution ($R^2$) for response of dependence variables ($Y$) for independence variables ($X$) of safflower genotypes (data over seasons and genotypes)

<table>
<thead>
<tr>
<th>Independence variables ($X$)</th>
<th>Dependence variables ($Y$)</th>
<th>Regression equation</th>
<th>$R^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pant height</td>
<td>Seed yield</td>
<td>$Y = 28.3X-3429$</td>
<td>30.9**</td>
</tr>
<tr>
<td></td>
<td>Oil yield</td>
<td>$Y = 10.5X-1325$</td>
<td>32.1**</td>
</tr>
<tr>
<td>Branches per plant</td>
<td>Seed yield</td>
<td>$Y = 968X-853$</td>
<td>33.8**</td>
</tr>
<tr>
<td></td>
<td>Oil yield</td>
<td>$Y = 132X-888$</td>
<td>34.0**</td>
</tr>
<tr>
<td>Capitula per plant</td>
<td>Seed yield</td>
<td>$Y = 110X-420$</td>
<td>38.4**</td>
</tr>
<tr>
<td></td>
<td>Oil yield</td>
<td>$Y = 39.8X-223$</td>
<td>39.6**</td>
</tr>
<tr>
<td>1000-seed weight</td>
<td>Seed yield</td>
<td>$Y = 17.3X+980$</td>
<td>3.0**</td>
</tr>
<tr>
<td></td>
<td>Oil yield</td>
<td>$Y = 6.15X+283$</td>
<td>3.0**</td>
</tr>
<tr>
<td>Seed weight per plant</td>
<td>Seed yield</td>
<td>$Y = 37.1X+100$</td>
<td>70.0**</td>
</tr>
<tr>
<td></td>
<td>Oil yield</td>
<td>$Y = 27.1X-46.9$</td>
<td>74.5**</td>
</tr>
<tr>
<td>Seed oil content (%)</td>
<td>Seed yield</td>
<td>$Y = 149X-3059$</td>
<td>41.3**</td>
</tr>
<tr>
<td></td>
<td>Oil yield</td>
<td>$Y = 59.4X-1344$</td>
<td>50.5**</td>
</tr>
</tbody>
</table>
| Seed yield                  | Oil yield                   | $Y = 0.000024X^2 + 0.276X-5.15$ | 98.1** | *(and **): Significant at 0.05 and 0.01 probability levels, respectively

CONCLUSION

According to the results obtained, there were significant differences of genotypes ($p<0.01$) on all studied traits. Line-1682 gave the highest values for all studied traits except the highest 1000-seed weight was obtained from Line-1687. On the other hand, Line-1679 gave the lowest values for all studied traits except the lowest 1000-seed weight and oil content were obtained from Line-1671 and Line-1668, respectively. Positive and significant relationships between oil yield and all studied traits were found. Oil yield increased linearly with all studied traits, but there was a positive quadratic response in a safflower oil yield as the seed yield increased.

REFERENCES


