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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-1668, respectively. Oil yield expressed firm correlation with, plant height (r = 0.566**), branches per plant (r = 0.591**), capitula per plant (r = 0.625**), 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 Asteracea. 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.*, 2006).

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 (Tuncturk and Ciftci, 2004). In a research with 23 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 79 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 (74.5% 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 (60×15 cm). The preceding crop was sunflower in both seasons. The N, P_2O_5 and K_2O 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×year interaction effects, while genotypes were significant ($p<0.01$) on all studied traits.

Table 1: The origin safflower genotypes

Genotypes	Origin
Giza 1 (local check)	Egypt
Line-1697	Cyprus
Line-152	India
Line-1667	Ethiopia
Line-1675	Ethiopia
Line-154	India
Line-1671	Cyprus
Line-1668	Cyprus
Line-147	India
Line-1682	Cyprus
Line-1698	Cyprus
Line-143	India
Line-1687	Ethiopia
Line-1678	Cyprus
Line-1692	Ethiopia
Line-153	India
Line-150	India
Line-1690	Cyprus
Line-151	India
Line-1693	Ethiopia
Line-149	India
Line-1679	Ethiopia
Line-1677	Ethiopia
Line-156	India
Line-159	India

Table 2: Combined analysis of variance of safflower traits across varying genotypes during 2009-2010 and 2010-2011 seasons

Source of variance	df	Plant height	No. of branches plant^{-1}	No. of capitula plant^{-1}	1000-seed weight	Seed weight plant^{-1}	Oil content %	Seeds yeild ha^{-1}	Oil yeild ha^{-1}
Years (Y)	1	351.14	0.027	1.131	11.93	5.354	1.938	28677	4794
Years (Rep.)	4	220.90	2.093	37.750	32.65	11.282	13.510	56122	8314
Genotypes (G)	24	547.45**	3.417**	45.300**	221.60**	326.600**	37.060**	266691**	345671**
G x Y	24	47.40	0.749	11.150	14.01	7.608	0.530	24231	3087
Error	96	103.77	0.637	7.140	10.23	6.654	3.147	16724	2108

**Significant at p<0.01

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). Koutroubas *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

Table 3: Means of traits measured in winter safflower genotypes

Genotypes	Plant height (cm)	No. of branches plant^{-1}	No. of capitula plant^{-1}	1000-seed weight (g)	Seed weight plant^{-1} (g)	Seed yield (kg ha^{-1})	Seed oil content (%)	Oil yield (kg ha^{-1})
Giza 1	183.8	7.500	22.24	38.82	30.98	2672	32.49	869
Line-1697	174.3	6.167	17.43	48.75	17.68	1352	31.24	423
Line-152	181.0	6.833	18.64	43.75	22.49	2131	30.20	644
Line-1667	177.2	6.500	17.41	41.05	19.72	1431	30.15	632
Line-1675	182.5	7.000	19.85	47.07	24.92	1846	33.07	610
Line-154	176.1	6.500	17.31	45.55	18.46	1222	29.97	367
Line-1671	180.8	6.833	18.54	30.17	20.96	1096	32.13	352
Line-1668	171.1	6.000	15.76	45.55	12.26	794	26.36	209
Line-147	181.3	7.667	22.26	31.02	28.25	2527	32.38	818
Line-1682	199.7	9.000	25.69	42.60	39.46	2846	36.50	1039
Line-1698	158.7	5.500	14.25	31.35	8.83	728	28.65	208
Line-143	167.3`	5.500	13.50	38.55	10.09	773	27.12	209
Line-1687	168.3	6.500	17.24	49.13	17.50	1888	30.67	579
Line-1678	186.6	7.000	20.19	45.48	25.33	2451	31.31	771
Line-1692	177.0	6.167	16.79	42.72	19.98	1372	31.12	427
Line-153	166.6	6.167	16.79	34..28	13.72	895	27.95	250
Line-150	167.5	6.333	17.72	33.65	12.19	824	29.59	244
Line-1690	185.3	6.500	18.36	45.30	26.99	2105	36.36	776
Line-151	173.3	6.167	16.98	35.25	15.35	1658	30.80	511
Line-1693	173.7	6.500	18.22	41.87	20.17	1538	30.30	466
Line-149	179.9	6.000	15.97	42.85	21.08	1007	31.57	318
Line-1679	151.5	5.333	12.84	39.12	6.09	512	27.40	141
Line-1677	179.1	6.500	18.28	43.97	23.28	2110	33.40	704
Line-156	177.4	6.500	18.28	38.05	18.38	1192	29.54	352
Line-159	174.2	6.667	18.89	31.93	21.79	1841	32.39	596
LSD at 5%	11.7	0.915	3.06	3.67	2.96	148	2.03	53

of Narkhede 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 Narkhede 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-1668 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 = 0.566**), 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 (2006), 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 4: Simple correlation coefficients among traits measured in safflower genotypes

Traits	1	2	3	4	5	6	7	8
Plant height	-	0.466**	0.454**	0.156^{ns}	0.628**	0.551**	0.489**	0.566**
Branches per plant		-	0.955**	-0.012^{ns}	0.614**	0.581**	0.432**	0.591**
Capitula per plant			-	-0.014^{ns}	0.629**	0.620**	0.441**	0.625**
1000-seed weight				-	0.147^{ns}	0.175*	0.119^{ns}	0.172*
Seed weight per plant					-	0.837**	0.673**	0.863**
Seed yield per ha						-	0.643**	0.990**
Seed oil content							-	0.711**
Oil yield per ha								-

* 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).

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)

Independence variables (X)	Dependence variables (Y)	Regression equation	R^2 (%)
Pant height	Seed yield	Y = 28.3X-3429	30.3**
	Oil yield	Y = 10.5X-1325	32.1**
Branches per plant	Seed yield	Y = 368X-853	33.8**
	Oil yield	Y = 135X-388	34.9**
Capitula per plant	Seed yield	Y = 110X-420	38.4**
	Oil yield	Y = 39.8X-223	39.0**
1000-seed weight	Seed yield	Y = 17.3X+980	3.0*
	Oil yield	Y = 6.15X+263	3.0*
Seed weight per plant	Seed yield	Y = 37.1X+100	70.0**
	Oil yield	Y = 27.1X-46.9	74.5**
Seed oil content (%)	Seed yield	Y = 149X-3059	41.3**
	Oil yield	Y = 59.4X-1344	50.5**
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, respectivly. 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

AOAC, 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington, DC., USA.

Alizadeh, K. and J. Carapetian, 2006. Genetic variation in a safflower germplasm grown in rainfed cold drylands. J. Agron., 5: 50-52.

Aslam, M. and G.R. Hazara, 1993. Evaluation of World Collection of Safflower (*Carthamus tinctorius* L) for Yield and Other Agronomic Characters. In: Third International Safflower Conference, Dajue, Dajue, L. and H. Yuanzhou (Eds.). Beijing Botanical Garden, Beijing, China, pp: 238.

Bagavan, I. and R.L. Ravikumar, 2011. Strong undesirable linkages between seed yield and oil and path analysis for grain and oil yield in spring safflower. Proceedings of the Vth International Safflower Conference, July 23-27, 2011, America, pp: 95-98.

Camas, N., C. Cirak and E. Esendal, 2007. Seed yield, oil content and fatty acids composition of safflower *Carthamus tintorius* grown in Northern Turkey condition. J. Fac. Agric., 22: 98-104.

Deharo, A., R.M. Del, J.C. Lopez, M.A. Garcia, M.J. Palomares and J.F. Martines, 1997. Evaluation of the world collection of safflower for oil quality and other seed characters. Sesame Safflower Newsl., 6: 94-99.

Ekin, Z., 2005. Resurgence of safflower (*Carthamus tinctorius* L.) utilization: A global view. J. Agron., 4: 83-87.

El-Gayar, M.A., A. El-Gawad and M.S. Barsoum, 1990. Differential behavior of some promising safflower mutant lines as affected by potassium fertilizer under calcareous soil conditions in Egypt. Proceedings of 4th Conference agronomy, September 15-16, 1990, Cairo, Egypt, pp: 13-28.

El-Lattief, E.A.A., F.S. Seedek and H.K.A. Rehab, 2009. Effect of irrigation and plant population density on productivity and water use efficiency of some genotypes of safflower (*Carthamus tinctorius* L.) under southern Egypt conditions. J. Agric. Sci. Mansoura Uni., 34: 257-267.

Eslam, B.P ., 2004. Evaluation of yield and yield components in new spring genotypes of safflower (*Carthamus tinctorius* L.). Proceedings of the Joint Agriculture and Natural Resources Symposium, May 14-16, 2004, Tabrez-Ganja.

Eslam, B.P., H. Monirifar and M.T. Ghassemi, 2010. Evaluation of late season drought effects on seed and oil yields in spring safflower genotypes. Turk. J. Agric. For., 34: 373-380.

Fernandez, J.M., D. Rio and A. de Haro, 1993. Survey of safflower (*Carthamus tinctorius* L.) germplasm for variants in fatty acid composition and other seed characters. Euphytica, 69: 115-122.

Han, Y. and D. Li, 1992. Evaluation of safflower (*Carthamus tinctorius* L.) germplasm-analysis in fatty acid composition of seeds of domestic and exotic safflower varieties. Bot. Res., 6: 28-35.

Johnson, R.C., P.B. Ghorpade and V.C. Bradley, 2001. Evaluation of the USDA core safflower collection for seven quantitative traits. Proceedings of the 5th International Safflower Conference, July 23-27, 2001, USA., pp: 143-149.

Kofidis, G., A.M. Bosabalidis and M. Moustakas, 2003. Contemporary seasonal and altitudinal variations of leaf structural features in oregano (*Origanum vulgare* L.). Ann. Bot., 92: 635-645.

Koutroubas, S.D., D.K. Papakosta and A. Doitsinis, 2004. Cultivar and seasonal effects on the contribution of pre-anthesis assimilates to safflower yield. Field Crops Res., 90: 263-274.

Mahasi, M.J., R.S. Pathak, F.N. Wachira, T.C. Riungu, M.G. Kinyua and J.W. Kamundia, 2006. Correlations and path coefficient analysis in exotic safflower (*Carthamus tinctorious* L.) genotypes tested in the arid and semi arid lands (Asals) of Kenya. Asian J. Plant Sci., 5: 1035-1038.

Mahasi, M.J., R.S. Pathak, F.N. Wachira, T.C. Riungu, and J.W. Kamundia, 2005. Development and evaluation of safflower (*Carthamus tinctorius* L.) cultivars for the marginal rainfall areas of Kenya: morphological characterization, genetic diversity and adaptation studies. Sesame Safflower Newsletter, 20: 68-75.

Mane, V.S., A.S. Jadhav and A.T. Powar, 1990. Effect of fertilizers and plant densities on the growth and yield of safflower. J. Maharashtra Agric. Univ., 15: 254-256.

McPherson, M.A., A.G. Good, Topinka and L.M. Hall, 2004. Theoretical hybridization potential of transgenic safflower (*Carthamus tinctorius* L.) with weedy relatives in the New World. Can. J. Plant Sci., 84: 923-934.

Mundel, H.H., H.C. Huang and J.P. Braun, 1999. Registration of lesaf 414, an early-maturing safflower germplasm line. Crop Sci., 39: 300-301.

Narkhede, B.N. and A.M. Patil, 1990. Phenotypic stability in safflower. J. Maharashtra Agric. Univ., 15: 95-96.

Omidi Tabrizi, A.H., 2006. Stability and adaptability estimates of some safflower cultivars and lins in different environmental conditions. J. Agric. Sci. Technol., 8: 141-151.

Parameshwarappa, K.G. and R.D. Meghannavar, 2001. Combining hybridization and irradiation for enhancing genetic variability in early segregating generations of safflower crosses. Proceedings of the 5th International Safflower Conference, July 23-27, 2001, Williston, North Dakota and Sidney, pp: 179-184.

Pascual-Villalobos, M.J. and N. Alburquerque, 1996. Genetic variation of a safflower germplasm collection grown as a winter crop in Southern Spain. Euphytica, 92: 327-332.

Tuncturk, M. and V. Ciftci, 2004. Relationships among traits using correlation and path coefficient analysis in safflower (*Carthamus tinctorius* L.) sown different fertilization levels and row spacing. Asian J. Plant Sci., 3: 683-686.

Weiss, E.A., 2000. Oilseed Crops. Blackwell Science, London, Pages: 364.