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GENETIC EVALUATION OF EARLINESS AND SPINELESS SAFFLOWER MUTANT LINES FOR QUANTITATIVE AND OIL CONTENT CRITERIA

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ABSTRACT: This investigation was carried out at experimental and research Farm, Faculty of Agriculture, Zagazig University, Egypt during six winter seasons 2012/2013, 2013/2014, 2014/2015, 2015/2016, 2016/2017 and 2017/2018. The aim of this study is to evaluate earliness and spineless mutant lines of safflower. The morphological traits (earliness, number of days to maturity) were recorded for two lines of safflower, line III and line VI and their promising mutant lines. The results confirmed the stability of 8 promising mutant lines for line III, (4, 7, 9, 10, 12, 14, 17, 18) and 6 promising mutant lines for line VI, (1, 2, 5, 6, 9, 7). In the M10 generation, 9 criteria were recorded, 1-plant height (cm), 2-number of branches per plant, 3-number of capitula per plant, 4-number of seeds per capitulam,5-number of seeds per plant, 6-100 seed weight (g), 7-seed weight/plant (g), 8-days to maturity, 9- oil (%). High broad sense heritability (h^2) of No. of capitula per plant, 100-seed weight, seed weight per plant, days to maturity and oil content were 79.16%, 77.95%, 94.91%, 79.23% and 69.41%, respectively among line III and their mutant lines. The present study confirmed that the relationship between characters under study varied between genotypes for example, oil content slightly negative correlated with seed weight per plant and was different among genotypes (-0.2495, -0.0678 and - 0.2358) for line III and line VI and for over all genotypes, respectively. These results confirmed that selection of oil content and seed weight per plant could be achieved in line VI and their mutants (- 0.0678). In addition, highly positive correlation between seed weight per plant and each of No. of capitula per plant and No. of seeds per plant at line VI, was observed. These results showed the simple heritable system of days to maturity, than the spineless criteria. These promising mutant lines had 168 and 170 days to maturity of line 4 and 7 from line III and 177 and 182 days of line 2 and 5 from line VI by comparison to 180 and 188 days for control of line III and line VI, respectively. These results suggest the improvement possibility of new Egyptian varieties for cultivation of harsh and poor land desert.

Key words: Safflower (*Carthamus tinctorius* L.), earliness, spineless, quantitative, heritability (h^2), oil content, correlation coefficients (r).

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) 2n = 24 chromosomes, family Asteraceae is one of the oldest domesticated crops. It has been grown since ancient times both as a dye and as an oil crop in a wide range of geographical regions (**Knowles, 1976**). (**Weiss, 1971**) reported that safflower has been recorded as being grown for centuries in a wide area covering southern and western China, much of India and westward across present-day Pakistan, Afghanistan, Iran, Iraq, northern Saudia Arabia, Kazakhstan, Turkey, and numerous other middle eastern countries, as well down Nile valley of Egypt, Sudan, and Ethiopia.

The western expansion of the arabs in creating the muslim empire of the 5th and 6th centuries probably helped the cultivation of safflower along the Maghreb and into Europe. Safflower seeds have been found in 4,000 year-old Egyptian tombs and their use were recorded

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in China approximately 2,200 years ago. The flowers of the safflower plant have long been used as a source of yellow and red dyes for clothing and food. The petals have also been used for medical purposes and as a stimulant for blood circulation and phlegm reduction, and for healing fractures, contusions, and strains (**Smith and Jimmerson, 2005**).

Three principle products come from current safflower production: oil, meal, and birdseed. Oil is the primary product and has food and industrial uses. There are two types of safflower oil. The first oil is high in monounsaturated fatty acid (oleic) and the second is high in polyunsaturated fatty acid (linoleic). Oleic oils are used as cooking oils. Linoleic oil is used as a drying agent in paints and varnishes because linoleic oil does not yellow (**Smith and Jimmerson, 2005**).

Safflower is usually considered to be a self-pollinated crop. However, out-crossing between safflower crops has been reported to be anywhere from 0 to 100% (**Claassen, 1950**), Characteristics that have been used to measure out-crossing include allozymes, flower color, spiny versus non-spiny, dominant white seed hull versus recessive gray strip and high linoleic/ low oleic versus low linoleic/high oleic fatty acid content. High-oleic safflower oil is lower in saturates and higher in monounsaturates than olive oil and is beneficial in preventing coronary artery diseases and tend to lower blood levels of low density level (LDL) (bad cholesterol) without affecting high density level (HDL) (good cholesterol) (**Zhaomu and Lijie, 2001**).

In addition, safflower (*Carthamus tinctorius* L.) nowadays has gained the reputation of being an edible oil of superior quality containing high levels of unsaturated fatty acids, such as oleic and linoleic acids, associated with the reduction of cholesterol level in the human blood (**Chaturvedi *et al*., 2001**). It is also a source of important biochemicals like tocopherol in oil and carthamin in flowers (**Ramaswamy, 2001**). Safflower has a deep root system allowing the plant to utilize efficiently the nutrients that may not be available to small-grain crops. Hence, introduction of such crop will enhance the sustainability of the organic farming system and benefits consumers and farmers. Therefore the safflower has been introduced in organic farming in Central Europe.

Moreover, safflower can be grown successfully on soil with poor fertility and in areas with relatively low temperatures, safflower also classified as a moderately salt-tolerant plant (**Siddiqi *et al.*, 2007**). World production of safflower has decreased as the crop suffered from increased cultivation of sunflower, soya and rape (**Weiss, 2000**). The estimated world production is about 0.622 million tons of seed per year from about 0.736 million hectares (**FAO, 2009**). At recent statistics according to **FAO (2014)** statistics, safflower production in the world was realized on an area of 1,010,180 ha with a total world production reaching about 867,659 tons (**Yilmaz *et al*., 2016**).

Conventional breeding has not been effective in boosting the per-hectare yields of either "oil" or "seed". Genetic upgradation of the "ultimate product" in safflower is complicated, as it involves simultaneous improvement of seed yield and oil content. Such problems may alternatively be resolved by "Mutagenesis", where sufficient genetic variability for characters under consideration can be created. (**Khadeer and Anwar, 1991**) used large mutagens (γ –ray, EMS, NMU, and sodium azide SA). The results thus obtained, suggest that for a complex trait like oil quality and/or quantity, sufficient variability can be induced by mutagenesis besides polygenic traits and induced variability can be exploited by the breeder for the genetic improvement of desirable traits in safflower. Multiple investigations were done for induction of genetic variability by using mutagenesis (**Veena and Ravikumar, 2003; Velasco *et al*., 2005; Mozaffari and Asadi, 2006**).

In Egypt, safflower area decreased year after year at upper Egypt, because the local genotypes suffering many problems as lateness (180-190 days at maturity), full spine on leaf and petals, low seed yield and low seed oil content. Therefore the present study aimed to assess the

genetic evolution of promising mutant lines (earliness, spineless) for seed yield and oil content, and subsequently improvement of new commercial safflower varieties with economic beneficials in Egypt.

MATERIALS AND METHODES

Materials

This study continued during six generations (M5-M10 generations) for 27 mutant lines and their two parents (line III and line VI). These mutant lines were obtained from M.Sc. Thesis of **Ahmed (2012)** as a promising mutants, whereas spineless and earliness criteria (Table 1).

Methods

These lines were carried out at six generations from 2013 to 2018. The trial was laid out in randomized complete blocks design with 3 replications, accommodating 5 ridges, 60 cm apart, 4 m length with 15 cm plant to plant distance and seeding rate of 12 kg fad. Fertilization of nitrogen and phosphors were applied as common agriculture. Genotype seeds were sown by hand on 14th, November.

At M5 to M9, the spineless and days to maturity were recorded per each generation for stability study of these mutant lines. The criteria were recorded at M10 generation as follows: 1-plant height, 2-No. of branches per plant, 3-No.of capitula per plant, 4-No. of seeds per capitulam, 5-No. of seeds per plant, 6-100 seed weight (gm), 7-seed weight per plant (g), 8-Days to maturity, and 9- Oil content. Oil content of the samples was obtained using the soxhlet extraction method with hexane as described in **AOAC (1990)**.

Statistical Analysis

The collected data were analysed using the randomized complete blocks design (RCBD) according to **Gomez and Gomez (1984)** as analysis of variance and heritability estimates were recorded in the basis of **Singh and Chaudary (1977)**. The correlation coefficients were estimated between all criteria.

RESULTIS AND DISCUSSION

The stability and adaptability values of mutant lines under study were shown in Table 2. The results showed that line VI was more stable than line III, because of the death of 3 mutant lines only from 9 mutant lines, by comparison, it was 10 out of 18 for line III throw recurrent six years. Therefore, line VI and their mutants are more survival and adaptable than line III and their mutants. For homozygosity of spineless criteria at 3 generations (M8, M9 and M10 generation) where shown in two mutant lines, line 4 and line 7 at line III genotype. At line VI, two mutant lines (line 2 and line 5) were stable and adaptable at 3 years (M8, M9 and M10 generation). In general, spine formation is considered as a polygenic character, but the spineless mutant lines at line VI and line III over recurrent three years may confirm the likelihood of homozygous genotypes for this criterion. The survival of studied genotypes for days to maturity was shown in Table 3. In contrast, multiple mutant lines had the same days to maturity at 4 generations (4 years): Fortunately, the stable and adaptable mutant lines for spineless possessed earliness stability at 4 generations. These lines were line 4, and line 7 at line III genotype and line 2 and line 5 at line VI genotype. Moreover, survival mutant lines in two line genotypes and their mutants possessed high stablility, for days to maturity. These results weighted the simple heritable system of days to maturity, than the spineless criteria. These promising mutant lines had 168 and 170 of line 4 and 7 from line III and 177 and 182 days of line 2 and 5 from line VI by comparison to 180 and 188 days for control of line III and line VI, respectively. These results suggest the possibility of new inhancement, in Egyptian varieties for cultivation of harsh and poor land desert. These varities possessed spineless and earliness and so they can be used as forage crop.

These results are agreeded with **Ragab *et al.* (2008)**, they were studying spineless safflower mutant lines for seed oil content and fatty acid profiles. The results showed a changeable for these mutant lines than the mother variety in multiple criteria especially oil content.

Highly significant difference between genotypes of line III and their mutant lines for nine characters and line VI and their mutant lines for nine characters under study were shown in Tables 4 and 6. High broad sense heritability (h^2) of No. of capitula per plant,100-seed weight,

Table 1. Pedigree of mutant lines and their parents at fourth generation used in the present study(*)

No. of line	Pedigree	Source of mutant
Line III		
1	(3)-A-5-5	γ -ray 100Gy (spinyless - early)
2	(3)-B-7-2	γ -ray 100Gy (tip spine - early)
3	(4)-A-1-10	γ -ray 100Gy (tip spine - early)
4	(4)-B-2-8	γ -ray 100Gy (tip spine - early)
5	(4)-B-6-6	γ -ray 100Gy (tip spine – normal)
6	(5)-A-2-5	γ -ray 100Gy (tip spine – normal)
7	(5)-A-10-7	γ -ray 100Gy (tip spine – normal)
8	(5)-A-10-1	γ -ray 150Gy (spinyless – early)
9	(5)-B-3-4	γ -ray 150Gy (spinyless – early)
10	(5)-B-5-2	γ -ray 150Gy (spinyless – early)
11	(6)-A-7-6	γ -ray 150Gy (spinyless – early)
12	(7)-A-5-5	γ -ray 150Gy (spinyless – early)
13	(2)-A-3-7	γ -ray 150Gy (spinyless – early)
14	(3)-A-7-3	γ -ray 150 Gy (spinyless – early)
15	(5)-A-1-2	γ -ray 200Gy (spinyless – early)
16	(5)-B-1-4	γ -ray 200Gy (spinyless – early)
17	(6)-B-3-12	γ -ray 200Gy (tip spine – normal)
18	(7)-A-2-4	γ -ray 200Gy (tip spine – normal)
Line VI		
1	(2)-A-5-1	γ -ray 100Gy (spinyless – normal)
2	(2)-A-7-8	γ -ray 100Gy (spinyless – normal)
3	(2)-B-2-10	γ -ray 100Gy (spinyless – normal)
4	(3)-A-1-2	γ -ray 150Gy (spinyless – normal)
5	(3)-A-7-3	γ -ray 150Gy (spinyless – normal)
6	(7)-A-2-4	NaN3:0.003M 3hs (spinyless – early)
7	(7)-A-6-2	NaN3:0.003M 4hs (spinyless – normal)
8	(6)-A-1-5	NaN3:0.003M 4hs (spinyless – normal)
9	(7)-A-5-2	NaN3:0.003M 4hs (spinyless – normal)

Note: for example (3)-A-5-5, First number (3) as second generation,

Third No. (A-5) as third generation, (5) as No. of fourth generation.

*These materials from M.Sc. thesis of **Marwa Ahmed (2012)**

Table 2. The stability of safflower line III, line VI and their promising mutants for spine formation at M5 to M10 generations

No. of line	Genotype	M5			M6			M7			M8			M9			M10		
		S	T	F	S	T	F	S	T	F	S	T	F	S	T	F	S	T	F
Line III	Control	-	-	F	-	-	F	-	-	F	-	-	F	-	-	F	-	-	F
1	(3)-A-5-5	S	T	-	S	T	F	-	T	F	-	-	F	D	D	D	D	D	D
2	(3)-B-7-2	S	-	-	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
3	(4)-A-1-10	S	-	-	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
4	(4)-B-2-8	S	-	-	S	T	F	S	T	-	S	-	-	S	-	-	S	-	-
5	(4)-B-6-6	S	-	-	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
6	(5)-A-2-5	S	-	-	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
7	(5)-A-10-7	S	-	-	S	T	F	S	T	-	S	-	-	S	-	-	S	-	-
8	(5)-A-10-1	S	-	-	S	T	-	S	T	-	S	-	-	D	D	D	D	D	D
9	(5)-B-3-4	S	-	-	S	T	-	S	T	-	S	-	-	-	T	-	S	-	-
10	(5)-B-5-2	S	-	-	S	T	F	S	-	-	S	T	-	S	-	-	S	-	-
11	(6)-A-7-6	S	-	-	S	T	F	D	D	D	D	D	D	D	D	D	D	D	D
12	(7)-A-5-5	S	-	-	S	T	F	S	T	-	S	-	-	S	T	-	S	-	-
13	(2)-A-3-7	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
14	(3)-A-7-3	S	-	-	-	T	F	S	-	F	-	T	-	S	T	-	S	-	-
15	(5)-A-1-2	-	T	-	S	T	-	D	D	D	D	D	D	D	D	D	D	D	D
16	(5)-B-1-4	S	-	-	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
17	(6)-B-3-12	S	-	-	S	T	F	S	-	-	-	T	-	S	T	-	S	-	-
18	(7)-A-2-4	S	-	-	S	T	F	S	T	F	S	-	-	S	T	-	S	-	-
Line VI	Control	-	-	F	-	-	F	-	-	F	-	-	F	-	-	F	-	-	F
1	(2)-A-5-1	S	-	-	S	T	F	S	-	-	S	T	-	S	-	-	S	-	-
2	(2)-A-7-8	S	-	-	S	T	F	S	-	-	S	-	-	S	-	-	S	-	-
3	(2)-B-2-10	S	-	-	S	T	F	D	D	D	D	D	D	D	D	D	D	D	D
4	(3)-A-1-2	S	-	-	S	T	-	S	-	-	-	T	-	D	D	D	D	D	D
5	(3)-A-7-3	S	-	-	S	T	-	S	T	-	S	-	-	S	-	-	S	-	-
6	(7)-A-2-4	S	-	-	S	T	-	S	-	-	S	-	F	S	-	-	S	-	-
7	(7)-A-6-2	S	-	-	S	T	F	S	-	-	S	T	-	S	-	-	S	-	-
8	(6)-A-1-5	S	-	-	-	T	F	D	D	D	D	D	D	D	D	D	D	D	D
9	(7)-A-5-2	S	-	-	S	T	F	S	T	-	S	T	-	S	T	-	S	-	-

D: died, S: spineless, T : tip spine, F: full spine

Table 3. The stability of safflower line III, line VI and their promising mutants for days to maturity at M5 to M10 generations

No. of line	Genotype	M5	M6	M7	M8	M9	M10
Line III	Control	180	180	180	180	180	180
1	(3)-A-5-5	175	170	168	D	D	D
2	(3)-B-7-2	180	D	D	D	D	D
3	(4)-A-1-10	180	D	D	D	D	D
4	(4)-B-2-8	180	175	168	168	168	168
5	(4)-B-6-6	180	D	D	D	D	D
6	(5)-A-2-5	180	D	D	D	D	D
7	(5)-A-10-7	180	180	170	170	170	170
8	(5)-A-10-1	170	180	166	166	D	D
9	(5)-B-3-4	170	180	168	168	168	168
10	(5)-B-5-2	163	165	168	168	168	168
11	(6)-A-7-6	175	175	D	D	D	D
12	(7)-A-5-5	175	175	172	172	172	172
13	(2)-A-3-7	D	D	D	D	D	D
14	(3)-A-7-3	170	170	172	172	172	172
15	(5)-A-1-2	175	180	D	D	D	D
16	(5)-B-1-4	180	D	D	D	D	D
17	(6)-B-3-12	175	170	175	175	175	175
18	(7)-A-2-4	175	170	175	175	175	175
Line VI	Control	188	188	188	188	188	188
1	(2)-A-5-1	177	177	177	182	177	177
2	(2)-A-7-8	182	182	177	177	177	177
3	(2)-B-2-10	177	177	D	D	D	D
4	(3)-A-1-2	177	177	177	177	D	D
5	(3)-A-7-3	177	177	182	182	182	182
6	(7)-A-2-4	177	177	180	177	182	182
7	(7)-A-6-2	177	177	177	177	177	177
8	(6)-A-1-5	177	177	D	D	D	D
9	(7)-A-5-2	177	177	180	182	180	180

Table 4. Mean sum of squares (MS) and heritability (h^2) of morphological, quantitive and oil content of safflower for line III and their promising mutant lines at M10 generations

Source of variation	d.f	Plant height (cm)	No. of branches per plant	No. of capitula per plant	No. of seeds per capitulam	No. of seeds per plant	100 seed weight per plant (g)	Seed weight per plant (g)	Days to maturity	Oil (%)
		MS	MS	MS	MS	MS	MS	MS	MS	MS
Replication	**3**	883.33**	45.11**	929.58**	661.07**	3020868.86**	8.9**	5554.22**	26.89**	16.25**
Treatment	**8**	566.94**	19.72**	763.4**	180.44**	1319106.37**	4.09**	1246.28**	62.00**	35.28**
Error	**24**	89.6	2.79	47.13	32.85	204517.26	0.27	140.8	3.81	3.5
h^2 in broad sense		57.11%	58.50%	79.16%	52.89%	57.67%	77.95%	94.91%	79.23%	69.41%

*Significant at 0.05., ** Significant at 0.01.

seed weight per plant, days to maturity and oil content were 79.16%, 77.95%, 94.91%, 79.23% and 69.41%, respectively among line III and their mutant lines. Among line VI and their mutants, high heritability were found for almost criteria expect No. of branches per plant. The fluctuation of heritability, estimates among line III and line VI and their mutants was detected because the variation among line VI and their mutants was larger than the line III and their mutants. So, these results may be important for line VI and their mutants, which, they are recorded as a stable and adaptable. These results showed that the high estimation of heritability increases the efficiency of selection for a special trait. The selection of high oil content and good seed yield could be effective for development of new genotypes possessing high oil content and seed yield. Heritability is a good indicator of the transmission of traits from parents to progeny. The assessment of heritability helps in selection of the best genotypes from a varied genetic population, **Reddy *et al.* (2013).** They also reported that heritability, could be grouped as low (below 30%), medium (30-60%) and high (above 60%). **Tahernezhad *et al.* (2018)**, studied the broad sense heritability of safflower genotypes for many criteria. They classified it into groups on the basis of their heritability; group1 had high heritability and comprised plant height, days to flowering, 1000-seed weight, number of seed per capitula. These traits are less influenced by the environment and are strongly controlled by genetic factors. The highest broad sense heritability was estimated for plant height, which is in accordance with the results of **Mozaffri and Asadi (2006), Camas and Esendal (2006) and Elfadl *et al* (2010)**. The present results confirmed with the above results in many criteria under studies.

Average mean of quantitative characters and oil content were shown in Table 5 of line III and their mutants. These results showed that line 4 and 7 are considered as earliness (168 and 170 days to maturity) with no effect in seed yield and its components, but, these lines possessed low oil content. Very important line was reported of line 14 for significant oil content and subsequently, it facted high oil content, with no effect of seed yield and its components. In contrast lines 12 and 17 had high oil content, with low seed yield and its components.

So, line VI and their mutants exhibited a large variation and excellent genotypes may be selected for genetic improvement of oil content and seed yield (Table 7). Line 2 had 23.75 with comparison to 20.10 oil content, as well as earliness (177) and highly significant of No. of seeds per capitulum. In addition, line 6 had highly significance for 100-seed weight. Interesting remark, line 7 possessed short stature (138.25 cm) with comparison of mother plant (210 cm). Reduced plant height is an important trait in plant breeding, mainly because short genotype is more resistant to lodging than standard types (**Austin *et al.*, 1980; Fick and Miller, 1997**).

Relationship among studied traits using correlation coefficient was recorded in Tables 8, 9 and 10 of line III and line VI and their mutants and all most genotypes of line III and line VI and their mutants, respectively. **Maluszynski *et al.* (2002)** stated that induced mutation has been extensively used for creating new genetic variation in crop plant.

Table 5. Average mean of morphological, quantitive and oil content of safflower for line III and their promising mutant line at M10 generation

No. of line	Genotype	Plant height (cm)	No. of branches per plant	No. of capitula per plant	No. of seeds per capitulam	No. of seeds per plant	100 seed weight per plant (g)	Seed weight per plant (g)	Days to maturity	Oil (%)
Control III	Control	199.00	12.11	48.00	29.25	1600.00	7.86	78.25	180	18.00
4	(4).B.2.8	183.25	9.25	49.00	37.00	1825.00	4.96	66.75	168	14.00
7	(5).A.10.7	210.00	11.00	44.25	39.75	1885.25	5.70	76.75	170	18.00
9	(5).B.3.4	198.00	15.00	55.75	39.50	2499.55	5.50	80.00	168	16.00
10	(5).B.5.2	193.75	12.25	48.00	34.25	1621.00	7.50	83.25	168	20.00
12	(7).A.5.5	185.00	11.75	28.75	19.75	593.25	5.63	31.75	172	22.00
14	(3).A.7.3	203.25	10	25.25	41.00	1137.25	6.56	81.75	172	23.00
17	(6).B.3.12	221.75	9.25	41.00	34.00	1442.00	5.48	57.75	175	18.00
18	(7).A.2.4	196.75	12.25	31.00	32.33	1008.25	6.9	57.75	172	21.00
Average		198.97	11.42	41.22	34.09	1512.39	6.23	68.22	171.66	18.88
LSD		13.80	2.47	10.01	8.35	661.60	0.74	17.31	2.84	2.72

Table 6. Mean sum of squares (MS) and heritability (h^2) of morphological, quantitive and oil content of safflower for line VI and their promising mutant lines at M10 generation

Source of variation	d.f	Plant height (cm)	No. of branches per plant	No. of capitula per plant	No. of seeds per capitulam	No. of seeds per plant	100 seed weight per plant (g)	Seed weight per plant (g)	Days to maturity	Oil (%)
		MS	MS	MS	MS	MS	MS	MS	MS	MS
Replication	**3**	493.33**	59.43**	551.29**	203.85**	1068359.81**	2.87**	1646.14**	28.81**	49.23**
Treatment	**6**	3699.5**	72.12**	581.31**	174.39**	1093613.9**	2.72**	1580.66**	60.57**	27.28**
Error	**18**	55.39	11.15	54.23	7.345	128975.48	0.19	137.12	1.14	3.62
h^2 in broad sense		94.26%	57.74%	70.84%	85.04%	65.15%	76.82%	72.46%	92.89%	61.99%

Table 7. Average mean of morphological, quantitive and oil content of safflower for line VI and promising mutant line at M10 generation

No. of line	Genotype	Plant height (cm)	No. of branches per plant	No. of capitula per plant	No. of seeds per capitulam	No. of seeds per plant	100 seed weight per plant (g)	Seed weight per plant (g)	Days to maturity	Oil (%)
Control VI	Control	210.00	9.80	39.96	39.10	1500.00	5.43	68.00	188	20.10
1	(2).A.5.1	203.25	14.00	40.50	42.00	1754.50	5.86	81.75	177	19.00
2	(2).A.7.8	200.00	6.25	23.00	47.25	1087.25	5.33	51.75	177	23.75
5	(3).A.7.3	236.25	9.25	43.00	35.25	1520.50	4.76	61.75	182	18.25
6	(7).A.2.4	199.00	7.00	32.25	34.75	1113.25	7.26	46.75	182	22.00
9	(7).A.5.2	203.25	17.25	42.75	34.00	1579.25	5.66	68.33	180	20.25
7	(7).A.6.2	138.25	7.25	25.75	30.75	772.50	6.50	28.25	177	19.25
Average		198.57	10.11	35.31	37.58	1332.46	5.83	58.08	179.58	20.37
LSD		11.05	4.96	10.93	3.99	533.5	1.40	17.39	1.57	2.72

Table 8. Correlation coefficients (r) between morphological, quantitive characters and oil content for line III and their promising mutant lines at M10 generation

	Plant height (cm)	No. of branches per plant	No. of capitula per plant	No. of seeds per capitulam	No. of seeds per plant	100 seed weight per plant (g)	Seed weight per plant (g)	Days to maturity	Oil (%)
Plant height (cm)	1								
No. of branches per plant	-0.18999	1							
No. of capitula per plant	-0.01069	0.59634	1						
No. of seeds per capitulam	0.384579	-0.20051	0.102756	1					
No. of seeds per plant	0.154191	0.419155	0.820804*	0.585235	1				
100 seed weight per plant (g)	-0.00552	0.510804	0.233239	-0.16004	-0.07214	1			
Seed weight per plant (g)	0.23652	0.252031	0.486682	0.78233*	0.706959*	0.37683	1		
Days to maturity	0.357741	0.244312	0.229633	-0.40445	-0.16802	0.464061	-0.13108	1	
Oil (%)	0.048002	-0.05787	-0.70415*	-0.32854	-0.78095*	0.441373	-0.24951	0.204965	1

Table 9. Correlation coefficients (r) between morphological, quantitive characters and oil content for line VI and their promising mutant lines at M10 generation

	Plant height (cm)	No. of branches per plant	No. of capitula per plant	No. of seeds per capitulam	No. of seeds per plant	100 seed weight per plant (g)	Seed weight per plant (g)	Days to maturity	Oil (%)
Plant height (cm)	1								
No. of branches per plant	0.157703	1							
No. of capitula per plant	0.623717	0.283211	1						
No. of seeds per capitulam	0.436782	-0.24272	0.258644	1					
No. of seeds per plant	0.673646	0.272145	0.945751**	0.534343	1				
100 seed weight per plant (g)	-0.59854	-0.16046	-0.38758	-0.42496	-0.46588	1			
Seed weight per plant (g)	0.720736	0.459583	0.818887*	0.576391	0.938377**	-0.49132	1		
Days to maturity	0.319338	-0.35844	0.601946*	0.73089*	0.71198*	-0.07748	0.554386	1	
Oil (%)	0.037425	-0.45701	-0.23104	0.588352	-0.05752	0.163197	-0.06782	0.464857	1

Table 10. Correlation coefficients (r) as general between morphological, quantitive characters and oil content for line III and line VI and their promising mutant lines at M10 generation

	Plant height (cm)	No. of branches per plant	No. of capitula per plant	No. of seeds per capitulam	No. of seeds per plant	100 seed weight per plant (g)	Seed weight per plant (g)	Days to maturity	Oil (%)
Plant height (cm)	1								
No. of branches per plant	0.070251	1							
No. of capitula per plant	0.325329	0.432496	1						
No. of seeds per capitulam	0.365286	-0.3009	0.07448	1					
No. of seeds per plant	0.42571	0.325804	0.862658**	0.49557	1				
100 seed weight per plant (g)	-0.31398	0.197236	0.065226	-0.3142	-0.18609	1			
Seed weight per plant (g)	0.518248*	0.415106	0.642771**	0.548157*	0.800377**	0.061828	1		
Days to maturity	0.22017	-0.30292	0.082433	0.305862	0.056559	0.003403	-0.0428	1	
Oil (%)	0.040749	-0.30809	-0.58344*	0.100273	-0.54297	0.253417	-0.23587	0.432307	1

More than 2200 mutant varieties of different crops with improved agronomic traits have been developed and released to the farmers for general cultivation in the world. The present study confirmed that the relationship between characters under study varied between genotypes for example, oil content has slightly negative correlation with seed weight per plant and is different between genotypes (- 0.2495,- 0.0678 and - 0.2358) for line III and line VI and for all, respectively. Moreover, the selection of oil content and seed weight per plant could be achieved in line VI and their mutants (- 0.0678). In addition, highly positive correlation between seed weight per plant and no.of capitula per plant and No. of seeds per plant at line VI (Table 9), but is different at line III (Table 8).

As shown in Table 10 positive and highly significant correlation between seed weight per plant and three component traits, *i.e.* No. of capitula, No. of seeds per capitulum and No. of seeds per plant. Therefore, these three component traits are considered as important for selection of high seed weight per plant. Many relationship change from genotypes to the other and this fact confirm the importance of mutagenic treatments for enhancement of genetic variation. These results go agree with others (**Veena and Ravikumar, 2003; Pahlavani *et al.*, 2005; Mozaffari and Asadi, 2006**).

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التقييم الوراثى لسلالات القرطم الطفرية مبكرة النضج وعديمة الأشواك للصفات الكمية ومحتوى الزيت

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أجرى هذا البحث بالمزرعة التجريبية البحثية بكلية الزراعة، جامعة الزقازيق، مصر، خلال ستة مواسم شتوية ٢٠١٢/٢٠١٣، ٢٠١٣/٢٠١٤، ٢٠١٤/٢٠١٥، ٢٠١٥/٢٠١٦، ٢٠١٦/٢٠١٧، ٢٠١٧/٢٠١٨ بهدف تقييم سلالات القرطم الطافرة المبكرة وعديمة الشوك، تم دراسة الصفات المورفولوجية (التبكير، عدد الأيام للنضج) على سلالتين من القرطم، السلاله III والسلاله VIوطفراتهم، وقد أكدت النتائج ثبات ٨ سلالات طافرة للسلالة III (٤، ٧، ٩، ١٠، ١٢، ١٤، ١٧ و١٨) و ٦ سلالات طافره للسلاله VI (١، ٢، ٥، ٦، ٩ ، ٧)، في الجيل الطفرى العاشر تم دراسة ٩ صفات، ١- ارتفاع النبات (سم) ،٢- عدد الفروع لكل نبات، ٣-عدد الأقراص لكل نبات، ٤-عدد البذور لكل قرص، ٥- عدد البذور لكل نبات (جم) ، ٦- وزن ١٠٠ بذرة نبات (جم)، ٧- وزن البذورللنبات (جم)، ٨- عدد الأيام للنضج، ٩- محتوى الزيت، وكانت أعلى نسبة للمكافئ الوراثى بالمعنى الواسع لعدد الأقراص للنبات ووزن ١٠٠ بذرة ووزن البذور للنبات والأيام للنضج ومحتوى الزيت ٧٩,١٦ %، ٧٧,٩٥%، ٩٤,٩١%، ٧٩,٢٣% و٦٩,٤١% على التوالي بين السلاله III وطفراتها، أكدت الدراسة الحالية أن التغيرات في العلاقة بين الصفات تحت الدراسة من الأنماط الجينية أكثر من الأخرى، على سبيل المثال، محتوى الزيت يرتبط ارتباطا سالبا بوزن البذور لكل نبات ومختلف بين الأنماط الجينية (- ٠,٢٤٩٥ ، - ٠,٠٦٧٨ - ٠,٢٣٥٨) للسلاله III والسلاله VI وكلاهما على التوالي، وقد أكدت هذه النتائج اختيار محتوى الزيت ووزن البذور لكل نبات في السلاله VI وطفراتها (- ٠,٠٦٧٨)، وبالإضافة إلى ذلك، هناك علاقة إيجابية قوية بين وزن البذور لكل نبات وعدد الأقراص لكل نبات وعدد البذور لكل نبات في السلالة VI ، ولكنها مختلفة للسلالة III ، هذه النتائج أكدت التوارث البسيط لعدد الأيام للنضج، عنه فى صفة عدم وجود الشوك، هذه السلالات الطافرة تشمل ١٦٨ و١٧٠ يوماً للنضج للسلالات ٤ و ٧ من السلالة III و ١٧٧ و١٨٢ يومًا من النضج للسلالات ٢ و ٥ من السلالة VI مقارنة بالأيام للنضج١٨٠ و ١٨٨ يومًا للسلالة III والسلالة VI على التوالي، أكدت هذه النتائج إمكانية تحسين الأصناف المصرية لتلائم الزراعة تحت ظروف الأراضي الصحراوية الفقيرة والقاسية.

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