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RESPONSE OF SOME PROMISING SAFFLOWER GENOTYPES TO NITROGEN LEVELS UNDER DRIP IRRIGATION IN WADI EL-NATROON

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ABSTRACT

Two field experiments were carried out at the Agricultural Experiments Desert Station of the Faculty of Agriculture, Cairo University in Wadi El-Natroon, El-Beheira Governorate, during 2006/2007 and 2007/2008 seasons to study the response of 6 local and 7 introduced safflower genotypes to four nitrogen levels (30,45,60 and 75 kg N/fad) under drip irrigation system. The objectives of this research were to find out the best genotype(s) to be grown under the stress conditions (sandy soil and salinity irrigation water of 2560-2650 ppm) and to determine the optimum nitrogen level for each genotype. Nitrogen level of 75 kg N/fad recorded the highest values of plant height, number of branches/plant, number of capitula/plant, number of seeds/capitulum, seed yield/plant, seed index, seed oil percentage, seed and oil yield/fad, as well as, water use efficiency (WUE). Two local genotypes (Bani-Suef and Aswan), as well as, three exotic genotypes, (Demo-137, S-350 and Turkey-168) surpassed the other genotypes in seed yield, oil yield/fad and WUE. The interaction between nitrogen levels and genotypes was significant for seed oil percentage, seed yield, oil yield and WUE. The highest seed yield and WUE were realized for Bani-Suef genotype fertilized with 60 kg N/fad. Meanwhile, the highest oil yield was achieved under 75 kg N/fad by the exotic genotype Turkey-168. The correlation study showed significant positive association between seed yield and most studied characters.

Key words: ***Carthamus tinctorius, Safflower, Genotypes, Nitrogen, Reclaimed soils, Drip irrigation, Correlation coefficients, WUE.***

INTRODUCTION

The local edible oil production, in Egypt, is not sufficient. There is a vast gap (90%) between production and consumption (FAO 2004). This gap is mainly due to the limited area devoted to oil crops and increasing the average of oil consumption per capita from 12 kg to 14 kg. Consequently, the previous reasons reflect our exigent need to direct more attention to oil crops especially winter oil crops such as safflower and canola.

Safflower is one of the promising oil seed crops, which may play an important role in increasing edible oil production in Egypt. Its oil is nutritionally similar to olive oil but much less costly. Oleic safflower oil tend to lower blood levels of low-density lipoprotein, LDL (bad cholesterol), without affecting high-density lipoprotein, HDL (good cholesterol), (Smith, 1996). Recently, an important approach via biotechnology was developed for safflower as a new source of similar human insulin by a Canadian biotechnology company. It can produce over one kilogram of insulin per acre of safflower production, which is enough to supply 2500 patients for one year (Nancy 2006). Such approach may encourage small farmers in developing countries to grow safflower on large areas.

Safflower is a deep-rooted crop which can tolerate water stress (Drodas and Sioulas 2009). It is capable to produce a high seed yield with minimum water requirements (Sharaan *et al* 1991). The salinity of the ground water causes less seed yield reduction of 15 % and total biomass by 12 % compared with a well-watered crop in the same soil (Soppe and Ayars 2003). The chance of planting safflower, in the winter season in Delta and Nile valley, faces high competition with various major winter crops. The newly reclaimed soils offer a great opportunity to expand safflower planting due to its ability to withstand stress conditions in these soils such as poor or low soil quality, salinity, water stress, sodicity problems and limitation of water resources. The main obstacles for planting safflower are the limited genotypic materials and their narow genetic background with respect to adaptation to these conditions in Egypt.

Ghanem and Ash-Shormillesy (2007), as well as, Leilah *et al.* (1992) stated that with increasing nitrogen level, seed yield/plant was significantly increased. Also, Mündel *et al* (2004) recorded similar result with seed yield/unit area. On the contrary, Elfadl (2007) found that the nitrogen rate did not have a significant impact on plant height, seeds/plant, number of branches and heads/plant, seed yield, as well as, oil yield. This may be interpreted as ability of safflower to use residual soil-N efficiently.

Yield and yield components of safflower were significantly affected by the genotypes (Camas *et al* 2007, Eslam 2004, Mokhtassi-Bidgoli *et al* 2007, Fernández-Martinez *et al* 1993, Osman and Ali 2006, Sharaan *et al* 1991, Uslu *et al* 1998 and Muñoz-Valenzuela *et al* 2007). By contrast, Samanci and Ozkaynak (2003) found no significant differences among safflower genotypes in seed yield. Meanwhile, they recorded significant differences among genotypes in oil content. Osman and Ali (2006) reported that the introduced lines surpassed the local cultivar in water use efficiency.

The objectives of this research are: to find out the best genotype (s) to be grown under stress in Egypt conditions and to determine the optimum nitrogen level for these genotypes under drip irrigation system.

MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Experiments Desert Station, Faculty of Agriculture, Cairo University in Wadi El-Natroon, El-Beheira Governorate, during the two successive winter

Table 1. Physical and chemical properties of soil in 2006-07 and 2007-08 seasons.

Soil properties	Seasons	
	2006/2007	2007/2008
	Site 1	Site 2
Physical properties		
Sand %	93.52	92.33
Silt %	4.35	5.42
Clay %	2.13	2.25
Texture	Sandy	Sandy
Chemical properties		
Soil (pH)	7.85	7.80
Ec (ds/m)	8.08	7.80
Organic Matter (%)	0.21	0.29
Total $CaCo_3$ (%)	2.50	2.60
Total N (%)	0.50	0.60
Soluble anions concentration (meq/L) (meq/100g soil)		
Cl^-	80.75	77.0
HCO_3^-	0.45	0.50
SO_4^-	0.54	0.50
Soluble cations concentration (meq/L) (meq/100g soil)		
Na^+	46.44	52.0
K^+	0.51	1.00
Ca^{++}	18.20	8.00
Mg^{++}	15.51	17.0

Table 2. Chemical analysis of water sample in 2006 and 2007 years.

Year	pH	EC		Ions concentration meq/L						
	Unit	ds/m	PPM	HCO_3^- + CO_3^-	Cl^-	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^+	K^+
2006	7.54	4.00	2560	4.0	32.5	9.25	4.0	6.0	35.2	0.54
2007	7.48	4.14	2650	3.5	30.3	7.43	5.50	4.50	30.8	0.43

seasons of 2006/2007 and 2007/2008. The mechanical and chemical analysis of the soil and water analysis were carried out by the Reclamation and Development Center for desert soils, Faculty of Agriculture, Cairo University. The analyses are presented in Tables (1) and (2).

Table (1) reveals that soil of the experimental site was considered sandy, saline and poor in nutrients (N P K), as well as, organic matter. Also, Table (2) refers that irrigation water is saline and poor in nutrients. Two field experiments were conducted under drip irrigation system. Each experiment included 52 treatments which were the combinations of:

1- Four nitrogen levels, *viz.*, 30, 45, 60 and 75 kg N/ fad (fad =

$4200m^2$).

2- Thirteen genotypes (Table 3). Six of these genotypes, were local entries including Giza-1, the sole cultivar grown in Egypt and 5 genotypes (land races) collected from 5 Governorates as farmer's seed lots representing upper, middle and north Egypt. The remaining seven safflower genotypes were imported by Oil Seed Crops Research Program, Field Crops Research Institute, Agricultural Research Center (ARC), Egyptian Ministry of Agriculture.

Table 3. Sources of safflower genotypes.

Entry code	Safflower genotypes	Country	Source
1	Giza-1 cv. (middle Egypt)	Egypt	ARC
2	Monofiya (north Egypt)		Ashmoon center
3	Bani-Suef (middle Egypt)		Somosta center
4	Al-Minya (middle Egypt)		Malawi center
5	Aswan (upper Egypt)		Daraw center
6	Al-Wadi Al-Jadid (upper Egypt)		Al-Kharga center
7	Demo-137 cv.	USA	ARC
8	S-350 cv.	USA	
9	Line -1697	Cyprus	
10	Line -1699	Ethiopia	
11	Line -152	India	
12	Line -159	Turkey	
13	Line -168	Turkey	

A split-plot design in a randomized complete block arrangement with three replications was used. The main plots were devoted to the nitrogen levels and sub-plots to the genotypes. Each experimental unit consisted of four rows, 0.75 meter apart and 3 meter long. The sub-plot area was 9 m^2 (3 × 3 m). Seeds were sown by hand in hills 16 cm apart on 15 October in both seasons. Plant density (70000 plant/fad) was adjusted via seedlings thinning to two plants/hill at 30 days after sowing to avoid competition between plants.

All plots were fertilized with 30 kg P_2O_5/fad before planting in the form of single super-phosphate (15.5% P_2O_5) as one dose. Fifty kg K_2O/fad in the form of potassium sulphate (50% K_2O) was added through five equal doses. The first dose was added at 60 days from planting, and then the rest doses were applied at 7-day intervals. Nitrogen was added at levels of 30, 45, 60 or 75 kg N/fad, in the form of ammonium nitrate (33.5% N). These levels were added at 7-day intervals. Mixture of micronutrients was also sprayed as a foliar application after thinning at 21-day intervals. All suitable agricultural practices were conducted in the proper time.

Studied characters

Ten plants were randomly taken from the two central rows of each plot at harvest to measure the following characters: plant height (cm), number of branches/plant, number of capitula/plant, number of seeds/capitulum, seed yield/plant (g), seed index (100-seed weight g). Seed oil percentage was determined according to AOAC (2000). Seed yield (kg/fad) was determined by weighing produced seeds from each plot. Oil yield (kg/fad) was calculated by multiplying oil percentage by seed yield/fad. Water use efficiency (WUE kg/m^3) was calculated according to the following formula described by Kanber *et al* (1993):

WUE = Yield (kg) / the seasonal amount of applied water (m^3).

Data obtained from each season of the study were statistically analyzed according to procedures outlined by Gomez and Gomez (1984) using MSTAT-C computer program (Freed *et al* 1989). Test for homogeneity of variance was used to compare between variances over two years before deciding the validity of combined analysis. The differences among treatments means were compared by Least Significant Differences test (LSD) at 0.05 level of probability.

RESULTS AND DISCUSSION

Effect of nitrogen

Data in Table (4) revealed that plant height, number of branches/plant, number of capitula/plant, number of seeds/capitulum, seed yield/plant, seed index, seed oil percentage, seed and oil yield/fad, as well as, WUE were significantly affected by nitrogen levels. Number of plants/fad at harvest was not affected by N levels.

Table 4. Effect of nitrogen levels on some characters of safflower under drip irrigation (combined data of 2006-07 and 2007-08 seasons).

Character	Nitrogen levels (kg/fad)				$LSD_{0.05}$
	30	45	60	75	
Number of plants (1000/fad)	67.81	68.00	67.98	68.06	NS
Plant height (cm)	105.4	109.8	113.2	116.9	1.7
Number of branches/plant	7.4	8.4	9.4	10.2	0.4
Number of capitula/plant	14.1	16.4	18.8	21.6	2.0
Number of seeds/capitulum	17.6	20.6	22.9	26.0	1.4
Seed yield/plant (g)	12.24	14.42	16.97	19.05	0.63
Seed index (g)	5.15	5.65	6.07	6.73	0.14
Seed oil percentage (%)	32.12	32.76	33.68	34.46	0.49
Seed yield (kg/fad)	578.9	704.6	851.7	861.3	24.4
Oil yield (kg/fad)	187.2	232.1	288.1	297.6	9.65
Water use efficiency (kg/m^3)	0.294	0.358	0.433	0.438	0.011

NS = not significant

Table (4) shows that N increased plant height and number of branches up to 75 kg N/fad. These increases reflect the importance of N application in sandy soil which is low in fertility (Table 1). Similar trends were obtained by Drodas and Sioulas (2009) who reported that N fertilization promoted the safflower growth. While, Leilah *et al* (1992) explained these increases which might be due to the role of N on meristemic activity and cell division which in turn increased cell number and size. Also, Table (4) shows that number of capitula/plant was increased by adding N to 75 kg. Increasing number of branches/plant may be the main cause of this increase. Results in the same table revealed that seed yield/plant was increased by increasing N levels up to 75 kg N/fad. Such increase may be attributed to the increase in number of branches/plant, number of capitula/plant and number of seeds/capitulum.

Combined data in Table (4), showed that increasing N levels markedly increased seed index. Similar results were obtained by Strasil and Vorlicek (2002). This increase may be explained by higher dry matter accumulation partitioned to seeds (Leilah *et al* 1992). N fertilization increased also seed oil percentage. However, there was no significant difference between 60 and 75 kg N /fad. On the contrary, Engel and Bergman (1997), as well as, Leilah *et al* (1992) stated that nitrogen fertilizer had a little effect on seed oil content. Abu-Hagaza (1991), Afifi (1991) and El-Nakhlawy (1991) found insignificant effect of nitrogen levels on seed oil percentage.

Table (4) shows that N significantly increased seed yield/fad, however, no significant difference was observed between 60 and 75 kg N/fad. Such increase in seed yield/fad may be attributed to the considerable increase in plant height, number of branches/plant, number of capitula/plant, number of seeds/capitulum, seed yield/plant and seed index. Drodas and Sioulas (2009) reported that N fertilization promoted the safflower growth and increased dry matter yield, translocation and seed yield.

With respect to oil yield, it was significantly increased by nitrogen application (Table 4). This increase may be due to the increase in seed oil percentage and seed yield/fad. These results are in general agreement with those obtained by Abo-Shetaia (1990), as well as, Siddiqui and Oad (2006). On the contrary, Engel and Bergman (1997) cleared that oil yield was depressed significantly by excess of N fertilization.

It was also obvious from Table (4) that WUE was significantly increased by nitrogen application from 0.294 kg/m^3 under 30 kg N to 0.438 kg/m^3 when 75 kg N/fad was applied. Such superiority in WUE may be attributed to the increase in seed yield/fad. Nimje (1991) reported that the WUE was increased by nitrogen application.

Effect of genotypes

Combined data in Table (5) cleared that there were significant differences among all genotypes in plant height, number of branches/plant, number of capitula/plant, number of seeds/capitulum, seed yield/plant and seed index. While, no significant differences were observed among genotypes in number of plants/fad. In general, exotic genotypes, especially Turkey-159, recorded the shortest plant height when compared to the local ones. While, Al-Wadi Al-Jadid followed by Bani-Suef lines recorded the maximum plant height. Significant differences were recorded among genotypes concerning number of branches/plant. The local genotype Bani-Suef and the exotic genotype Turkey-168 followed by Demo-137 and Aswan produced the highest number of capitula/plant.

Data in Table (5) also revealed that both the exotic genotypes, Turkey-168 and Demo-137 had higher number of seeds/capitulum. In general, Bani-Suef and Aswan lines recorded the highest seed yield/plant. Generally, this superiority may be due to the increase in number of branches/plant, number of capitula/plant, number of seeds/capitulum, seed yield/plant and seed index. Concerning seed oil content Cyprus-1697, Turkey-168 and India-152 followed by the local genotype Monofiya surpassed the rest of genotypes (Table 5). Samanci and Ozkaynak (2003) reported significant differences in oil content due to different genotypes.

In general, five promising safflower genotypes (2 locals, Bani-Suef and Aswan) and 3 exotics, namely, Demo-137, S-350 and Turkey-168 outyielded the other genotypes in seed yield/fad (Table 5). This superiority may be a result of the increase in number of branches/plant, number of capitula/plant, number of seeds/capitulum, seed yield/plant and seed index. Effects of adaptability to climatic and edaphic Egyptian conditions during source and sink phases may no be ruled out. These results are in harmony with those obtained by Camas *et al* (2007), Eslam (2004), Fernández-Martinez *et al* (1993), Mokhtassi-Bidgoli *et al* (2007), Osman and Ali (2006), Sharaan *et al* (1991), Uslu *et al* (1998) and Muñoz-Valenzuela *et al* (2007) who reported that there were significant differences among genotypes studied. On the other hand, Samanci and Ozkaynak (2003) found no significant difference among safflower genotypes used with respect to seed yield. Also, Osman and Ali (2006) reported that some introduced lines surpassed the commercial cultivar Giza-1.

Differences in oil yield/fad due to genotypes were significant. Bani-Suef, a local land race and Demo-137, as well as, Turkey-168, the exotic genotypes outyielded other genotypes in oil yield (Table 5). Such superiority may be attributed to the increase in seed yield (Bani-Suef) and/or oil content (Turkey-168).

Table 5. Performance of some safflower genotypes under drip irrigation (combined data of 2006-07 and 2007-08 seasons).

Character / Genotype	Number of plants (1000/fad)	Plant height (cm)	Number of branches/ plant	Number of capitula/ plant	Number of seeds/ capitulum	Seed yield/ plant (g)	Seed index (g)	Seed oil percentage (%)	Seed yield (kg/fad)	Oil yield (kg/fad)	WUE (kg/m^3)
Giza-1	67.84	111.8	8.9	18.3	22.0	15.80	6.20	32.07	768.2	250.4	0.390
Monofiya	68.13	115.5	9.0	18.6	23.4	15.69	6.04	34.09	796.9	273.7	0.405
Bani-Suef	68.15	120.4	9.7	19.7	22.6	17.76	6.78	33.93	874.0	298.1	0.444
Al-Minya	68.02	118.6	8.7	15.9	21.7	14.91	5.06	32.76	574.6	188.3	0.292
Aswan	68.19	115.6	9.1	18.9	24.2	16.84	6.33	31.47	847.0	268.0	0.431
Al-Wadi Al-Jadid	68.10	123.2	8.5	14.6	21.4	13.88	4.83	31.82	502.7	160.8	0.256
Demo-137	68.07	108.0	9.1	19.5	26.1	16.82	6.19	32.94	831.9	276.0	0.423
S-350	67.88	106.1	8.8	17.9	19.6	16.23	6.15	32.12	808.9	260.8	0.411
Cyprus-1697	67.86	103.3	8.6	16.7	20.8	15.12	5.80	35.32	731.9	259.9	0.372
Ethiopia-1699	68.06	109.2	8.7	18.2	20.8	15.15	5.90	32.50	740.1	242.9	0.376
India-152	67.90	104.2	8.6	17.1	19.1	15.09	5.85	34.22	752.1	259.9	0.382
Turkey-159	67.38	99.9	8.3	15.6	16.8	14.36	5.51	33.99	706.1	243.4	0.359
Turkey-168	67.92	111.3	9.3	19.8	24.8	16.06	6.06	35.08	804.1	283.7	0.409
$LSD_{0.05}$	**NS**	**5.3**	**0.6**	**2.6**	**3.1**	**1.03**	**0.39**	**1.44**	**46.9**	**19.22**	**0.025**

NS = not

Results in Table (5) showed that genotypes differed significantly in their WUE. The highest values of WUE were obtained from two local land races (Bani-Suef and Aswan) and Demo-137 followed by Turkey-168 and S-350. These genotypes may be adapted to drought tolerance. They have good ability to consume little amount of water for producing high seed yield. These five genotypes are valuable in any breeding program for drought tolerance. Besides, Bani-Suef shows the highest seed and oil yields (Table 5).

Effect of the interaction

No significant interaction between N levels and genotypes used was detected for number of plants/fad, plant height, number of branches/plant, number of capitula/plant, number of seeds/capitulum, seed yield/plant and seed index.

Table 6. Seed oil percentage of safflower genotypes as affected by nitrogen levels and their interactions under drip irrigation (combined data of 2006-07 and 2007-08 seasons).

Genotype	Nitrogen level (kg/fad)				Mean
	30	45	60	75	
Giza-1	30.10	32.32	31.63	34.21	**32.07**
Monofiya	33.50	32.64	35.33	34.90	**34.09**
Bani-Suef	33.25	35.20	34.51	32.77	**33.93**
Al-Minya	31.31	33.39	30.90	35.43	**32.76**
Aswan	29.34	32.97	31.77	31.82	**31.47**
Al-Wadi Al-Jadid	27.92	32.14	33.41	33.83	**31.82**
Demo-137	31.97	31.57	33.77	34.44	**32.94**
S-350	31.04	32.52	33.19	31.75	**32.12**
Cyprus-1697	37.45	31.62	36.02	36.18	**35.32**
Ethiopia-1699	31.36	31.40	32.33	34.93	**32.50**
India-152	32.63	33.79	36.50	33.98	**34.22**
Turkey-159	31.43	35.16	34.12	35.25	**33.99**
Turkey-168	36.29	31.20	34.35	38.48	**35.08**
Mean	**32.12**	**32.76**	**33.68**	**34.46**	**33.25**
$LSD_{0.05}$ N × G					**2.88**

Results in Table (6) showed the effect of the interaction between nitrogen levels and safflower genotypes on seed oil percentage. Results revealed that the interaction had a significant effect on seed oil percentage. The highest seed oil percentage was obtained from the interaction of

Turkey-168 × 75 kg N/fad (38.48 %) followed by India-152 and Aswan × 60 kg N/fad (36.50 %) without significant differences.

The effect of the interaction between nitrogen levels and safflower genotypes on seed yield/fad is presented in Table (7). Results revealed that the interaction had a significant effect on seed yield/fad. The highest seed yield was obtained from the interaction of Bani-Suef × 60 kg N/fad (1010.7 kg/fad) followed by Aswan and Demo-137 × 60 kg N (1003.7 and 960.3 kg/fad, respectively). However, the differences among Bani-Suef, Aswan and Demo-137 × 60 kg N were insignificant. It seems that these genotypes are efficient with respect to N-uptake. They achieved their highest productivity and superiority among other entries with only 60 kg N/fad. The lowest seed yield/fad was recorded by the local genotype Al-Wadi Al-Jadid × 30 kg nitrogen followed by the exotic Turkey-159 × 60 kg nitrogen.

Table 7. Seed yield (kg/fad) of safflower genotypes as affected by nitrogen levels and their interactions under drip irrigation (combined data of 2006-07 and 2007-08 seasons).

Genotype	Nitrogen level (kg/fad)				Mean
	30	45	60	75	
Giza-1	526.0	761.9	896.7	888.3	**768.2**
Monofiya	568.6	771.2	873.4	974.3	**796.9**
Bani-Suef	696.3	875.9	1010.7	913.2	**874.0**
Al-Minya	505.8	527.3	632.4	633.0	**574.6**
Aswan	683.8	769.7	1003.7	930.7	**847.0**
Al-Wadi Al-Jadid	424.2	479.6	561.5	545.6	**502.7**
Demo-137	682.9	750.5	960.3	934.0	**831.9**
S-350	678.8	784.7	897.4	875.0	**808.9**
Cyprus-1697	477.9	669.4	867.5	912.9	**731.9**
Ethiopia-1699	534.6	715.7	870.5	839.6	**740.1**
India-152	574.5	679.2	815.3	939.3	**752.1**
Turkey-159	456.2	650.0	821.6	896.7	**706.1**
Turkey-168	715.9	724.5	861.1	914.8	**804.1**
Mean	**578.9**	**704.6**	**851.7**	**861.3**	**749.1**
$LSD_{0.05}$ N × G					**93.78**

Results in Table (8) showed the effect of the interaction between nitrogen levels and safflower genotypes on oil yield/fad. Results revealed that the interaction had a significant effect on oil yield/fad. The highest oil yield was obtained from the interaction of Turkey-168 × 75 kg N/fad (351.5 kg/fad) followed by Bani-Suef × 60 kg N/fad and Monofiya × 75 kg N/fad (349.9 and 339.9 kg/fad, respectively) without significant differences.

Table 8. Oil yield (kg/fad) of safflower genotypes as affected by nitrogen levels and their interactions under drip irrigation (combined data of 2006-07 and 2007-08 seasons).

Genotype	Nitrogen level (kg/fad)				Mean
	30	45	60	75	
Giza-1	159.8	247.4	284.7	309.6	**250.4**
Monofiya	191.2	253.3	310.3	339.9	**273.7**
Bani-Suef	231.8	310.2	349.9	300.7	**298.1**
Al-Minya	157.8	176.3	195.2	223.9	**188.3**
Aswan	200.7	256.0	318.4	297.0	**268.0**
Al-Wadi Al-Jadid	117.7	154.2	187.9	183.3	**160.8**
Demo-137	219.0	238.2	324.4	322.3	**276.0**
S-350	211.3	254.6	298.3	278.9	**260.8**
Cyprus-1697	179.7	213.3	316.7	329.7	**259.9**
Ethiopia-1699	169.8	224.9	282.8	294.3	**242.9**
India-152	187.2	232.7	300.0	319.9	**259.9**
Turkey-159	145.2	229.5	281.3	317.8	**243.4**
Turkey-168	261.8	226.4	295.0	351.5	**283.7**
Mean	**187.2**	**232.1**	**288.1**	**297.6**	**251.2**
$LSD_{0.05}$ N × G					**38.45**

The effect of nitrogen levels × safflower genotypes interaction on WUE is present in Table (9). Data indicated that interaction between the two factors under this research had a significant effect on WUE. The highest WUE was obtained from Bani-Suef × 60 kg N (0.514 kg/m^3) followed by genotype Aswan × 60 kg N. (0.510 kg/m^3).

The product moment correlation coefficients between seed yield/fad and most traits was significant and positive Table (10). Significant and positive association was observed between seed yield/fad and number of branches/plant (0.68*), number of capitula/plant (0.89**), seed yield/plant (0.85**), seed index (0.97**), oil yield/fad (0.97**) and WUE (0.96**). These results are in general agreements with those obtained by Tunçtürk and Vahdettin (2004) who found positive and significant relationships among seed yield and plant height, number of capitula/plant, 1000-seed weight, seed oil percentage and oil yield. Siddiqui and Oad (2006) showed that the crop attributes *viz.*, plant height, number of branches/plant, number of capsules/plant and seed index were also positively associated with the seed yield. Abu-Hagaza (1990) mentioned that seed yield/fad showed a significant positive correlation with seed yield/plant and seed index.

Table 9. Water use efficiency (kg/m^3) of safflower genotypes as affected by nitrogen levels and their interactions under drip irrigation (combined data of 2006-07 and 2007-08 seasons).

Genotype	Nitrogen level (kg/fad)				Mean
	30	45	60	75	
Giza-1	0.267	0.387	0.456	0.452	0.390
Monofiya	0.289	0.392	0.444	0.495	0.405
Bani-Suef	0.354	0.445	0.514	0.464	0.444
Al-Minya	0.257	0.268	0.321	0.322	0.292
Aswan	0.348	0.391	0.510	0.473	0.431
Al-Wadi Al-Jadid	0.216	0.244	0.285	0.277	0.256
Demo-137	0.347	0.381	0.488	0.475	0.423
S-350	0.345	0.399	0.456	0.445	0.411
Cyprus-1697	0.243	0.340	0.441	0.464	0.372
Ethiopia-1699	0.272	0.364	0.442	0.427	0.376
India-152	0.292	0.345	0.414	0.477	0.382
Turkey-159	0.232	0.330	0.418	0.456	0.359
Turkey-168	0.364	0.368	0.438	0.465	0.409
Mean	0.294	0.358	0.433	0.438	0.381
$LSD_{0.05}$ N × G					0.051

Besides, Camas *et al* (2007) found that seed yield/ha was correlated with other characters in the following order, oil yield, oil content, number of branches/plant, 1000-seed weight and number of seeds/head. In addition, Mokhtassi-Bidgoli *et al* (2007) reported that high yielding genotypes were found to be closely related to1000-seed weight, number of capitula/plant, number of seeds/capitulum and harvest index.

CONCLUSION

Seed yield of safflower was increased by nitrogen application up to 60 kg in some local land races (N-efficient land races) and 75 kg for other entries. The level of 60 kg N/fad is recommended for economical yield where the difference between 60 and 75 kg was insignificant. Seed yield/fad is very closely and significantly related to oil yield and seed index (r=0.97) and to less extent to number of capitula/plant (r=0.89) and seed yield from single plant (r=0.85).

Two promising local genotypes (Bani-Suef and Aswan), as well as, 3 exotics (Demo-137, S-350 and Turkey-168) recorded higher seed and oil yields. These genotypes may be grown successfully under stress conditions in Egypt. The highest seed yield was obtained from Bani-Suef received 60 kg N/fad. On the other hand, Cyprus-1697 and Turkey-168 recorded higher oil content (35.32% and 35.02%, respectively) when compared to the local and commercial cultivar Giza-1 (32.07%).

Table 10. Correlation coefficients between safflower characters under drip irrigation (combined data of 2006-07 and 2007-08 seasons).

Characters	Seed yield (kg/fad)	Number of plants (1000/fad)	Plant height (cm)	Number of branches/ plant	Number of capitula / plant	Number of seeds/ Capitulum	Seed yield/ plant (g)	Seed index (g)	Seed oil (%)	Oil yield (kg/fad)
Number of plants (1000/fad)	0.13	1								
Plant height (cm)	-0.27	0.73**	1							
Number of branches/ Plant	0.68*	0.57*	0.44	1						
Number of capitula/Plant	0.89**	0.40	0.04	0.86**	1					
Number of seeds/Capitulum	0.36	0.70**	0.48	0.72**	0.67*	1				
Seed yield/plant (g)	0.85**	0.44	0.17	0.91**	0.88**	0.59*	1			
Seed index (g)	0.97**	0.23	-0.11	0.76**	0.89**	0.38	0.90**	1		
Seed oil (%)	0.20	-0.32	-0.40	0.09	0.12	-0.08	-0.01	0.12	1	
Oil yield (kg/fad)	0.97**	0.03	-0.34	0.65*	0.85**	0.31	0.78**	0.92**	0.44	1
WUE (kg/m^3)	0.96**	0.13	-0.27	0.68	0.89**	0.36	0.85**	0.97**	0.20	0.97**

REFERENCES

A.O.A.C (2000). Official methods of analysis of A.O.A.C. International.17th edition by Horwitz, W. Suite (ed.) Vol. (2), chapter (41): pp. 66-68.

Abo-Shetaia, A. M. A. (1990). Response of yield and yield components of safflower (*C. tinctorius*, L.) to increasing levels of nitrogen and phosphorus under two levels of plant density. Annals Agric. Sci., Fac. Ain Shams Univ., 35 (1):223-241.

Abu-Hagaza, N. M. (1990). Variability and inter-relationships between economic characters in safflower. Proc. 4th conf. Agron., Cairo, II, pp. 1-12.

Abu-Hagaza, N. M. (1991). Response of safflower to nitrogen levels, time of application and time of harvesting. *J. Agric. Mansoura Univ.* 17 (1):10-18.

Afifi, M. M. (1991). Effect of mineral fertilization and sowing dates on growth and yield of safflower plants (*C. tinctorius*, L.). Msc. Thesis, Fac. Agric. Ain Shams Univ.

Çamaş, N., Ç. Cüneyt and E. Enver (2007). Seed yield, oil content and fatty acids composition of safflower (*carthamus tinctorius* L.) grown in northern Turkey conditions. J. Fac. Agric., OMU, 22 (1):98-104.

Dordas, C. A. and C. Sioulas, (2009). Dry matter and nitrogen accumulation, partitioning, and retranslocation in safflower (*Carthamus tinctorius* L.) as affected by nitrogen fertilization. Field Crops Res., 110 (1):35-43.

Elfadl, E. (2007). Effect of nitrogen rate and seed density on safflower (*Carthamus tinctorius* L.) under low-input farming system. Conf. Tropentag, Witzenhausen, 9-11.

El-Nakhlawy, F. S. (1991). Response of safflower to different levels of nitrogen, phosphorus and potassium. Acta Agronomica Hungarica, 40 (1-2):87-92.

Engel, R. and J. Bergman, _ (1997). Safflower seed yield and oil content as affected by water and N. Fertilizer Facts, 14.

Eslam, B. P. (2004). Evaluation of yield and yield components in new spiny genotypes of safflower (*Carthamus tinctorius* L.). *The Joint Agric. and Natural Res. Symp., Tabriz – Ganja, May 14-16.*

FAO (2004). Imports and exports of selected agriculture commodities, Group III (table c. 18).
Cited in:http://www.fao.org/ag.

Fernández-Martinez, J. F.; M. Del 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 (1-2): 115-122.

Freed, R.; S. P., S. Einensmith, S. Gutez, D. Reicosky, V. W. Smail, and P. Wolberg, (1989). User's guide to MSTAT-C analysis of agronomic research experiments. Michigan Univ. East Lansing, USA.

Ghanem, S. A .I. and S. M. I. Ash-Shormillesy (2007). Effect of plant distribution and nitrogen fertilization on yield and photosynthates partitioning of safflower. Bull. Fac. Agric., Cairo Univ., 58:1-10.

Gomez, K. A. and A. A. Gomez, (1984). Statistical Procedures for Agricultural Research 2nd ed. (Eds. John Willey and Sons), New York, USA.

Kanber, R.; S. Onder, , M. Koksal, and E. K. Weatherhead (1993). Comparison

of surge and continuous faurrow methods in Harran Plain in GAP area. Final Report, on Irri. And soil Project., Adana, p.52.
Leilah, A. A.; A. E. Sherif, and El. M. Said, (1992). Effect of plant density and N fertilization on safflower (*Carthamus tinctorius*, L.) productivity. Proc. 5[th]. Conf. Agron., Zagazig, (2): p. 871-879.
Mokhtassi-Bidgoli, A., G. A. Akbari, M. J. Mirhadi, A. R. Pazoki, and S. Soufizadeh (2007). Yield components, leaf pigment contents, patterns of seed filling, dry matter, LAI and LAID of some safflower (*Carthamus tinctorius* L.) genotypes in Iran. *Pakistan J. Biol. Sci.,* 10 (9):1406-1413.
Mündel, H.-H., R. J. Morison, B. R. E.lackshaw, T. Entz, B. T. Roth, R. Gaudiel, and F. Kiehn, (1994). Seeding-date effects on yield, quality and maturity of safflower. Can. J. Plant Sci., 74: 261–266.
Mündel, H. H., E. Robert, J. Blackshaw, B. Robert, C., H. Henry, L. J. Daniel, K. Rick, K. Jerry, K. Ross, O. Brian, R. Blair, and S. Kim (2004). Safflower Production on the Canadian Prairies. Agriculture and Agri-Food Canada, Lethbridge Research Centre, Lethbridge, Alberta. pp.1-33.
Muñoz-Valenzuela, S., G. Chanda Musa, L. Montoya-Coronado and V. M. Rivera-Rojas, (2007). Evaluation of safflower genotypes in Northwest México. Issues In New Crops and New Uses. (Ed. J. Janick and A. Whipkey), ASHS Press, Alexandria, VA.
Nancy M., N. Cory, B. Joe and M. Maurice (2006). Producing proteins using transgenic plant in safflower.
Cited in:http://wwv' sembiosys.ca/Docs/FactSheet.pdf.
Nimje, P. M. (1991). Influence of irrigation and nitrogen on water use, yield and oil content of safflower. Indain, J. Agron., 36:165-168.
Osman, E. B. A. and A. Ali (2006). Response of some safflower genotypes to modern system of irrigation in sandy calcareous soils. Proc.1[st] Field Crops Conf. Egypt, pp. 363-371.
Samanci, B. and E. Ozkaynak (2003). Effect of planting date on seed yield, oil content and fatty acid composition of safflower (*Carthamus tinctorius*) cultivars grown in the Mediterranean region of Turkey. J. Agron. and crop Sci., 189: 359-360.
Sharaan, A. N., A. A. Kandil and N. M. Mahrouse (1991). Response of safflower to water stress in middle Egypt. *Assiut J. Agric. Sci.,* 22 (1):367-381.
Siddiqui, M. H. and F. C. Oad (2006). Nitrogen requirement of safflower (*Carthamus tinctorius* L.) for growth and yield traits. Asian J. Plant Sci. 5 (3):563-565.
Smith, J. R. (1996). Safflower. American Oil Chemists Society Press, Champaign, IL. USA. pp. 606.
Soppe, R.W.O. and J. E. Ayars (2003). Characterizing ground water use by safflower using weighing lysimeters. Agric. Water Manag. 60:59–71.
Strašil, Z. and Z. vorlíček (2002). The effect of nitrogen fertilization, sowing date and site on yield and yield components of selected varieties of safflower (*Carthamus tinctorius* L.). Rostlinnà Výroba 48 (7): 307-311.
Tunçtürk, M. and Ç. Vahdettin (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 (6):683-686.

Uslu, N., A. Ali, and M. Basri Halitligil (1998). Cultivar, weed and row spacing effects on some agronomic characters of safflower (*Carthamus tinctorius* L.) in spring planting. Turkey. J. Agric. and Forestry 22:533-536.

استجابة بعض التراكيب الوراثية المبشرة من القرطم لمستويات من التسميد النيتروجيني تحت نظام الري بالتنقيط بوادي النطرون

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أجريت تجربتان حقليتان بمحطة التجارب الزراعية الصحراوية لكلية الزراعة جامعة القاهرة بوادي النطرون، بمحافظة البحيرة (أرض رملية، وملوحة مياه الري ٢٥٦٠- ٢٦٥٠ جزء في المليون)، خلال موسمي ٢٠٠٦/٢٠٠٧ ، ٢٠٠٧/٢٠٠٨ لدراسة استجابة ٦ تراكيب وراثية محلية و٧مستوردات من القرطم (جيزة-١، المنوفية، بني سويف، المنيا، آسوان، الوادي الجديد، ديمو-١٣٧، إس-٣٥٠، قبرص-١٦٩٧، اثيوبيا-١٦٩٩، الهند-١٥٢، تركيا-١٥٩، تركيا-١٦٨) لأربع مستويات من التسميد النيتروجيني (٣٠، ٤٥، ٦٠، ٧٥ كجم ن/فدان) تحت نظام الري بالتنقيط وكذلك تأثير التفاعل بينهم علي المحصول ومكوناته. كان الهدف من هذا البحث إيجاد أفضل تركيب أوتراكيب وراثية للنمو تحت ظروف الاجهاد الصحراوي وتحديد المستوي الامثل من التسميد النتروجيني لهذه التراكيب. استُخدام تصميم القطع المنشقة مرة واحدة حيث وضعت مستويات التسميد النيتروجيني في القطع الرئيسية والتراكيب الوراثية من القرطم في القطع المنشقة. ويمكن تلخيص أهم النتائج فيما يلي: حقق مستوي التسميد النيتروجيني ٧٥ كجم ن/فدان أعلي قيم لصفات طول النبات، عدد أفرع النبات، عدد رؤوس النبات، عدد بذور الرأس، وزن بذور النبات، دليل البذرة، نسبة الزيت، محصول البذرة والزيت للفدان وكذلك كفاءة استخدام المياة. تفوق تركيبان وراثيان محليان هما (بني سويف وآسوان) وثلاثة تراكيب مستوردة هي (ديمو-١٣٧، إس-٣٥٠ وتركيا-١٦٨) علي باقي التركيب الوراثية الأخري في محصول البذور والزيت للفدان وكفاءة استخدام المياة. أظهر التفاعل بين مستويات التسميد النيتروجيني والتراكيب الوراثية تأثيراً معنوياً علي صفات نسبة الزيت بالبذور، محصول البذور، محصول الزيت وكفاءة استخدام المياة. تم الحصول علي أعلي محصول بذور وكفاءة استخدام مياة من التركيب الوراثي بني سويف عند تسميده بـ ٦٠ كجم ن/فدان. في حين تحقق أعلي محصول زيت تحت مستوي النيتروجين ٧٥ كجم ن/فدان مع التركيب الوراثي المستورد تركيا-١٦٨. أظهرت دراسة الارتباط بين محصول البذور ومعظم الصفات المدروسة ارتباطاً معنوياً موجباً.