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PERFORMANCE OF SUNFLOWER CULTIVATED IN SANDY SOILS AT A WIDE RANGE OF PLANTING DATES IN EGYPT

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ABSTRACT

In Egypt, newly reclaimed soils offer a great opportunity to increase the area devoted to oil-seed crops. The objectives of this research were to determine the optimum planting date(s) that achieve the highest seed and oil yields per unit land area and to determine the suitable cultivar for sandy soils of Wadi El-Natroon region, Egypt. As well as, study the changes in fatty acid profile entire year. The field experiments were conducted in the Desert Exp. Sta. Fac. Agric., Cairo Univ., Wadi El-Natroon, El-Beheira Governorate, Egypt under drip irrigation system in 2013 and 2014 years. Sakha-53 and Giza 102 sunflower cultivars were monthly planted, from January up to December. Results refers that there is a possibility of planting sunflower from February up to August in new reclaimed sandy soil under Egyptian conditions. The results revealed that seed yield fed^{-1} significantly varied among planting dates. The highest seed and oil yields fed^{-1} were obtained from 1st March planting (1038.3 and 400.1 kg fed^{-1}) followed by April planting (911.7 and 352.1 kg fed^{-1}). Sakha-53 surpassed Giza-102 in all studied traits. Concerning fatty acids composition results indicated that increasing growing temperatures resulted in more oleic acid and total unsaturated fatty acids. As well as, less linoleic acid and total saturated fatty acids. Seed yield fed^{-1} is very closely and significantly related to seed yield plant^{-1} (r=0.87), number of leaves plant^{-1} (r=0.83) and less extent to head diameter (r=0.75).

Keywords: *Helianthus annuus* L.*, Sunflower, Planting dates, Cultivar, Oil-seed, Fatty acids*, *Sandy soils, Wadi El-Natroon, Egypt.*

INTRODUCTION

The newly reclaimed soils in the desert of Egypt offer a great opportunity to expand oil crops really sunflower due to its ability to withstand climatic fluctuations and stress conditions such as temperature, photoperiod, salinity problems, soil infertility and limitation of water resources. Sunflower ranks with soya, canola and peanut as one of the four most important annual crops in the world grown for edible oil (FAO, 2013). Sunflower is a short duration, neutral photoperiod, relatively drought tolerant and adapted crop to a wide range of environment (Weiss, 2000). Numerous studies have shown that sunflower yield and yield components were significantly affected by different planting dates and cultivars.

Abd El-Mohsen (2013), Mahmood (2013), as well as, Aziz and Salih (2014) found that planting sunflower on March was increased plant height, head diameter and 1000-seed weight. Taller plants, larger head diameter, heavier 1000-seed weight and higher seed-oil % were obtained from planting on April (El-Sadek *et al.*, 2004 and Taha *et al.*, 2010). Moreover, planting on May recorded the tallest plants, maximum leaf area index, heaviest 1000-seed weight (El-Saied *et al.*, 1989 and Sharief, 1998), heaviest seed weight plant^{-1} (Sharief and Said, 1993; Salama 1996 and Sharief, 1998) and highest seed-oil % (Sharief, 1998). On the other hand, planting sunflower on June recorded higher values of plant height, head diameter and 1000-seed weight and seed weight plant^{-1} (Elkaramity *et al.*, 1998 and Abdou *et al.*, 2011). The optimum time of sunflower planting for achieving higher seed and oil yields fed^{-1} was determined by many investigators *i.e.*, early summer on April (El-Sadek *et al.*, 2004), May (El-Saied *et al.*, 1989; Sharief and Said, 1993; Salama, 1996 and Abd El-Mohsen, 2013), and late summer on June (Elkaramity *et al.*, 1998 and Abdou *et al.*, 2011).

Cultivars of sunflower significantly differed on plant height, head diameter, 1000-seed weight, seed-oil % and seed yield fed^{-1} (Elkaramity *et al.*, 1998); also cultivars significantly differed in plant height, leaf area index, head diameter, 1000-seed weight, seed weight plant^{-1}, seed-oil%, seed and oil yields fed^{-1} (Sharief, 1998). Taha *et al.* (2010) revealed that Sakha-53 surpassed Giza-102 cultivar in plant height, head diameter, 1000-seed weight, seed weight plant^{-1}, seed-oil%, seed and oil yields fed^{-1}. The interaction between planting date and cultivar significantly affected plant height, head diameter, 1000-seed weight and seed yield ha^{-1} (Elkaramity *et al.*, 1998); 1000-seed weight (Sharief, 1998) and oil yield fed^{-1} (Taha *et al.*, 2010). Conversely, Elkaramity *et al.* (1998) found insignificant effect for planting date × cultivar interaction on seed-oil %.

From the healthier point of view, sunflower oil is in the top of healthy vegetable oils. This view may be due to its higher content of an essential unsaturated fatty acid (USFA), linoleic (ω_6), and its lower content of long chain fatty acids, as well as, lower saturated fatty acid (SFA) content (Turhan *et al.*, 2010). Concerning fatty acids composition (FAC), planting dates induced changes in FA profile (Unger and Thompson 1982, De Vos *et al.*, 1985 and Rondanini *et al.,* 2003). Positive relationships were found among sunflower seed yield and plant height, leaf area index, head diameter, weight of thousand achen and seed-oil % (Sharief, 1998); seed yield plant^{-1}, 1000-seed weight and head diameter (Abd El-Mohsen, 2013). The growing degree days (GDD) or heat units (HU) is the most common index used to estimate plant development. The accumulation of these heat units determines the maturity of sunflower (Kaleem *et al.*, 2011a and b).

The objectives of the present research were to determine suitable planting date(s) and suitable cultivar could be recommended in sandy soils. As well as, study the changes in fatty acid profile entire planting dates.

MATERIALS AND METHODS

The field experiments were conducted in the Desert Exp. Sta., Fac. Agric., Cairo Univ. in Wadi El-Natroon, El-Beheira Governorate, (located between 30º32'30" and 30º33'0" N and between 29º57'15" and 29º58'15" E with an altitude of 31 and 59 m) during 2013 and 2014 years. Climatic data of experimental location are presented in Table (1). Tables 2 and 3, reveals that soil of the experimental site was sandy, saline and poor in NPK and organic matter. Also, irrigation water was saline.

Table 1. Mean monthly of climatic data at experimental location in Wadi El-Natroon* during 2013 and 2014 years.

Month	Temperature (ºC)		Relative humidity (%)		Wind speed (km h^{-1})
	Max.	Min.	Max.	Min.	
2013					
January	22.14	20.77	78.21	49.43	7.34
February	22.89	20.80	76.00	44.00	7.71
March	23.14	13.92	79.19	45.85	8.30
April	24.87	14.24	79.71	41.85	6.72
May	27.20	14.97	82.31	41.55	6.01
June	28.29	15.05	84.13	47.91	6.10
July	28.61	15.49	87.67	54.98	6.48
August	29.47	16.94	87.56	56.72	6.07
September	29.02	19.26	84.54	51.04	5.66
October	27.63	20.41	80.51	51.49	6.40
November	25.30	20.00	77.96	50.05	6.40
December	24.60	19.75	80.95	49.61	5.21
2014					
January	22.50	20.54	78.22	49.00	7.20
February	22.75	20.66	77.00	43.00	7.40
March	23.16	14.01	79.15	45.92	8.22
April	24.89	14.23	79.73	41.84	6.74
May	28.12	14.96	82.22	41.74	6.22
June	28.25	15.08	84.13	47.85	6.09
July	28.74	15.39	87.59	54.78	6.51
August	29.77	16.96	87.66	56.88	6.08
September	29.17	19.23	84.61	51.12	5.62
October	27.58	20.14	80.45	51.76	6.43
November	25.05	20.11	77.56	50.12	6.45
December	24.43	19.90	80.10	49.50	5.24

*** Data obtained from Wadi El-Natroon by the Central Laboratory for Agriculture Climate (CLAC), Agricultural Research Center, Egypt**

Table 2. Physical and chemical properties of soil at the experimental site in 2013 and 2014 years.

Soil analysis	2013	2014
Physical properties		
Sand %	94.85	92.50
Silt %	4.00	4.78
Clay %	1.15	2.72
Texture	Sandy	Sandy
Chemical properties		
Soil (pH)	7.89	7.53
Ec (dS/m)	5.23	5.36
Organic Matter (%)	0.30	0.25
Total $CaCo_3$ (%)	2.55	5.96
Available N (mg kg^{-1})	0.63	8.6
Available P (mg kg^{-1})	1.45	2.24
Available K (mg kg^{-1})	150	180

Table. 3. Chemical properties of irrigation water at the experimental site in 2013 and 2014 years.

Years	pH	EC			Ions concentration meq/L						
		dS/m	PPM		HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
2013	7.6	4.1	2624		2.9	30.1	9.0	3.9	4.3	33.3	0.64
2014	7.8	4.2	2688		3.5	28.8	7.7	5.5	4.5	31.6	0.54

The tested treatments were the combination of two Egyptian sunflower cultivars (Sakha-53 and Giza -102) and twelve planting dates started from beginning of January up to December in both seasons. Sunflower was preceded after fallow. Experimental design was split-plot in randomized complete block arrangements in three replications. The main plots were devoted to the twelve planting dates. The sub-plots were allotted to cultivars.

The experiments were laid out under drip irrigation system. Each experimental unit consisted of five ridges, each of 0.60 m in width and 5.0 m in length (15 m^2).

Seeds were sown in hills 20 cm apart on 15th October in both seasons. After 2 weeks from planting, plants were thinned to one plant/hill. Mono super phosphate fertilizer (15.5% P_2O_5) at rate of 30 kg P_2O_5 fed^{-1}(4200 m^2) was added during field preparation. Ammonium nitrate (33.5% N) at rate of 60 kg N fed^{-1} and potassium sulphate (48% K_2O) at rate of 48 kg K_2O fed^{-1} were added starting from 15 days after planting in six equal doses at 7-day interval. All the required cultural practices were adopted uniformly as necessary during the growing season. The heads were covered completely after pollination to prevent birds attack.

After 60 days from planting, ten plants were randomly taken from each plot to record number of leaves $plant^{-1}$ and leaf area index (measured using portable leaf area meter; Model LA-3000A). At harvest, ten guarded plants were randomly taken from each experimental unit to record the following characters: number of days to maturity, root length (cm), plant height (cm), head diameter (cm), thousand-seed weight (g) and seed weight $plant^{-1}$ (g). Daily seed weight $plant^{-1}$ (g) was calculated by dividing seed weight $plant^{-1}$ by number of days to maturity.

Seed oil percentage was determined according to AOAC (2000) using Soxthelt apparatus. Fatty acids were separated according to Vogel (1975) and identified by Gas Liquids Chromatography, Trace GC Ultra, Thermo Scientific (GLC) apparatus according to Farag *et al.* (1981). Also, seed yield per plot was weighed and converted to yield per feddan. Oil yield fed^{-1} was calculated by multiplying seed-oil percentage by seed yield fed^{-1}.

Cumulative growing degree days were calculated by the following equation: CGDD = $[(T_{Max} + T_{Min}) / 2 - T_b]$ Where; T_{Max} and T_{Min} are daily maximum and minimum air temperatures in degrees centigrade according to Dwyer and Stewart (1986). The base temperature (T_b) of sunflower is 8°C (Sadras and Hali, 1988).

Data were statistically analyzed according to procedures outlined by Steel *et al.* (1997) using MSTAT-C computer package (Freed *et al*. 1989). Test for homogeneity of variance was used to compare between error variances before deciding the validity of combined analysis. The least significant difference ($LSD_{0.05}$) test was used to compare among the means. The product moment correlation coefficients between seed yield fed^{-1} and all studied traits were estimated.

RESULTS AND DISCUSSION

Analysis of variance:

Combined analysis of variance in Table (4) show that the differences between years reached to the level of significance in leaf area index, 1000-seed weight, seed weight $plant^{-1}$, daily seed weight $plant^{-1}$ and oil yield fed^{-1}. These differences may be due to the differences among years in climatic parameters (Table 1). Also, highly significant differences were found among planting dates for all studied traits. These results are in harmony with those obtained by Abd El-Mohsen (2013) and Baghdadi *et al.* (2014) who found that significant differences among planting dates in number of days to maturity, plant height, number of leaves $plant^{-1}$, leaf area index, head diameter, 1000-seed weight, seed yield $plant^{-1}$ and seed yield ha^{-1}. Mean squares due to cultivars were also highly significant for all studied traits. All mean squares due to planting dates × cultivars interaction were highly significant for all traits, except 1000-seed weight, seed and oil yields fed^{-1} were insignificant. Coefficients of variation (C.V) for all studied traits were ranged from 0.1 to 5.2%.

Effect of planting dates:

Data in Table (4) reveal that number of days to maturity, root length, plant height, number of leaves $plant^{-1}$, leaf area index, head diameter, 1000-seed weight, seed weight $plant^{-1}$, daily seed weight $plant^{-1}$, seed-oil %, seed and oil yields fed^{-1} were significantly affected by planting dates.

Data presented in Table (5) show that number of days to maturity gradually decreased as a result to delaying planting from January up to June and then increased up to December. Planting on May and June recorded the lower number of days to maturity (68.9 and 68.5 day, respectively) than the other planting dates. Planting on November and December recorded the longest duration (90.9 and 93.8 day, respectively).

Results in Table (5) show that plants of March, April, May and June plantings had roots longer than those of the other planting dates. While August planting produced plants characterized by shorter roots. These results are not in agreement with those obtained by Aziz and Salih (2014) who found insignificant effect of planting dates on root depth. Sunflower plant height varied according to the different planting dates. The tallest plants were obtained from planting on September followed by planting on March (155.0 and 150.7cm, respectively). Higher temperature on September may lengthen the plants of sunflower Table (1). The same trend was observed by Mahmood (2013) and Aziz and Salih (2014), in Kurdistan, who found that the tallest plants were obtained from planting on March. On the other hand, Abdou *et al.* (2011), in Egypt, cleared that sunflower plants of July planting were the tallest.

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Results in Table (5) also showed that planting of sunflower on February, March, April and June gave higher number of leaves plant^{-1} than the other planting dates. Such increase on February and March may be due to the increase in plant height and the increase in temperature during these growing periods. The present findings are not coincide with those reported by Aziz and Salih (2014), who found that number of leaves plant^{-1} was not affected by planting date. Leaf area index significantly varied *via* planting dates, and the planting on September recorded the highest value (9.2) followed by planting on October (8.6). This result on September might be due to the increase in number of leaves plant^{-1}. Also, planting sunflower on May gave the largest head diameter (23.9 cm). Similar trends were obtained by Aziz and Salih (2014). On the other hand, the smallest head diameter was obtained from January planting.

Results in Table (5) recorded that higher values of 1000-seed weight were obtained from planting on February up to April. This increase may be related to the increase in head diameter of sunflower. Lower values of 1000-seed weight were obtained from June, July and January planting. These results are in accordance with those obtained by Mahmood (2013) and Aziz and Salih (2014). These results are not in agreement with those of Abdou *et al.* (2011) who reported that the largest head diameter and 1000-seed weight were obtained from planting on July and June, respectively.

Results of the present study also show that higher weight of seeds of the individual plant was obtained from planting on March, April and May. Such increase in seed weight plant^{-1} may be due to the increase in 1000-seed weight and root length. Similar trends were obtained by Mahmoud (2013), as well as, Aziz and Salih (2014), who reported that planting sunflower on March gave higher seed yield plant^{-1}. On the other hand, Abdou *et al.* (2011) found that planting on 1st July gave the highest seed yield plant^{-1}.

Results in Table (5) show that plants of March, April and May plantings had higher daily seed weight plant^{-1} than the other planting dates. While planting on December produced lower daily seed weight plant^{-1}. This results may be explain by sunflower was planted during early summer (March, April and May) passed lower temperature during early phases and completed their life cycle taking longer period. Meanwhile, sunflower was planted during later summer (June, July and August) had higher temperature during the early phases and completed their life cycle rapidly therefore had lower seed weight.

In this context, seed yield fed^{-1} (Table 5) significantly varied among planting dates. The highest seed yield fed^{-1} was obtained from March planting (1038.3 kg fed^{-1}) followed by April, February and May planting (911.7, 868.2 and 838.4 kg fed^{-1}, respectively). This superiority of the planting on March and April may be attributed to the considerable increase in seed yield plant^{-1} and 1000-seed weight. These trends are in harmony with those obtained by Mahmood (2013). On the other hand, Abdou *et al.* (2011) found that the highest seed yield fed^{-1} was obtained from planting on June. On the contrary, planting sunflower on January, December and November recorded the lowest seed yield (316.2, 403.2 and 420.3 kg fed^{-1}, respectively). Results in Table

(5) cleared that the same trend for seed-oil % and oil yield fed^{-1} which recorded the higher values by planting sunflower on March and April.

Effect of cultivars:

Results in Table (5) reveal that the two sunflower cultivars significantly varied in number of days to maturity, root length, plant height, number of leaves $plant^{-1}$, leaf area index, head diameter, 1000-seed weight, seed weight $plant^{-1}$, daily seed weight $plant^{-1}$, seed-oil %, as well as, seed and oil yields fed^{-1}. The highest values of all previous traits were obtained from the cultivar Sakha-53, except number of days to maturity. Giza-102 matured earlier than Sakha-53. Superiority of Sakha-53 cv. in seed and oil yields fed^{-1} may be due to their genetic constitution and its capability of withstanding climatic fluctuation and soil conditions than Giza-102 and related to the increase in root length, number of leaves $plant^{-1}$, leaf area index, head diameter, 1000-seed weight, seed weight $plant^{-1}$, daily seed weight $plant^{-1}$ and oil content. These results are in agreement with those obtained by Taha *et al.* (2010) who reported that Sakha-53 surpassed Giza-102 in plant height, head diameter, 1000-seed weight, seed weight $plant^{-1}$, seed oil%, seed and oil yields fed^{-1}.

Effect of the interaction between planting dates and cultivars:

Results in Table (4) reveal that the interaction between planting date and cultivar significantly affected all studied traits, except 1000-seed weight, seed and oil yields per feddan. The main cause of insignificant effect of planting date × cultivar interaction on seed and oil yields fad^{-1} may be due to the wide range of planting date from January to December which resulted in big error. The same trend was observed in Egypt by Elkaramity *et al.* (1998), Sharief (1998) and Taha *et al.* (2010). Besides, Elkaramity *et al.* (1998) found insignificant effect on seed-oil %.

Figure (1) clear the growing degree days (GDD) for each planting date of sunflower cultivars. Sunflower cultivars under evaluation exhibit differences for growing degree days accumulation during planting dates. Sakha-53 accumulated GDD more than Giza-102 via all planting dates. The maximum GDD (1328 and 1242) were obtained by the interaction of Sakha-53 cv. × planting on December and Giza-102 cv. × planting on November, respectively.

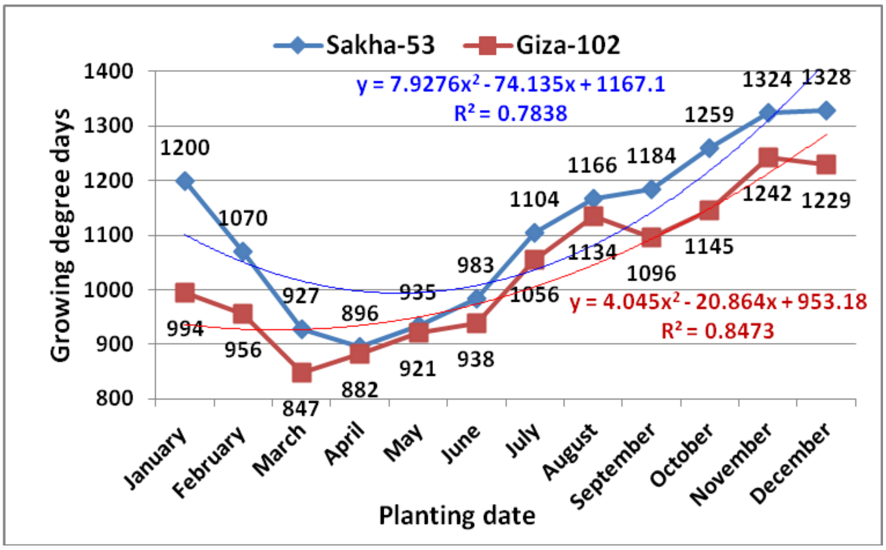

Fig. 1. Growing degree days for each planting date of sunflower cultivars.

While, the minimum GDD (847 and 896) were obtained from Giza-102 cv. × planting on March and Sakha-53 cv. × planting on April, respectively.

Figure (2) show that daily seed weight plant^{-1} was significantly affected by the interaction between planting date and cultivar. Daily seed weight plant^{-1} was increased gradually from January up to May planting after that decreased gradually up to December for both cultivars. It could be concluded that the planting in January, November and December led to the minimum daily seed yield for both cultivars. Also, Figure (2) show that Sakha-53 surpassed Giza-102 in daily seed weight plant^{-1} during the majority of plating dates.

Results in Table (6) show the effect of planting dates × sunflower cultivars interaction on fatty acids composition (combined data of 2013 and 2014 years). Results indicate that USFA were major components and the highest ratio in sunflower oil (oleic, linoleic and linoleinc) which were obtained by planting Sakha-53 and Giza-102 from March up to August. This means that sunflower oil is considered a good edible vegetable oil due to its lower content of SFA which were obtained the highest values from September to December for both cultivars. On the other side, saturated ones, palmitic and stearic were the major components. These results are in general agreement with those obtained by Unger and Thompson (1982), Rondanini *et al.* (2003) and Schulte *et al.* (2013).

Also, results show that Sakha-53 followed by Giza-102 cultivars are useful for development of healthier oils with high 18:2 (ω_6) and low SFA. Generally, we can increase 18:2 (ω_6) in seed oil content by planting sunflower from September to November. Schulte *et al.* (2013) indicated that increasing growing temperatures from 10 to 40° C will result in more monounsaturated oils and less polyunsaturated oils.

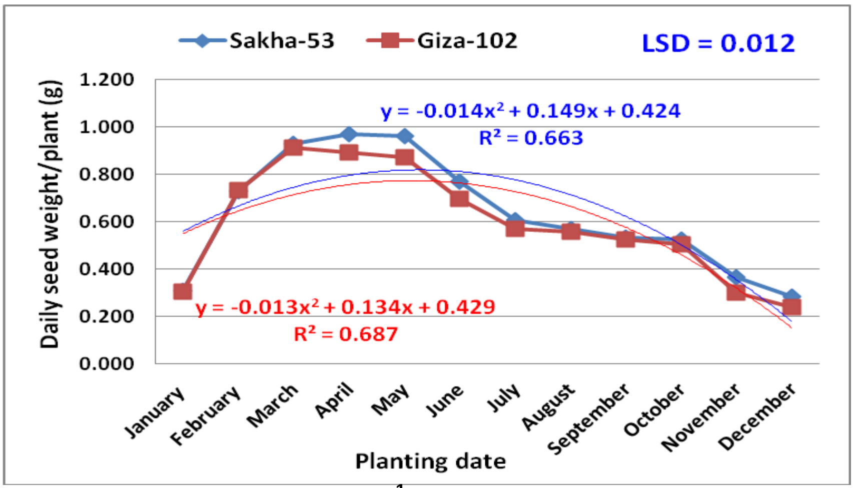

Fig. 2. Daily seed weight plant^{-1} (g) as affected by planting date × sunflower cultivar interaction.

Table 6. Relative percentage of fatty acid composition as affected by sunflower genotype × planting date interaction (combined data of 2013 and 2014 years).

Planting date	Fatty acid composition (FAC)						
	16:0	18:0	18:1	18:2 (ω_6)	18:3 (ω_3)	TSFA	TUFA
	Sakha-53						
January	6.50	5.74	15.00	60.70	6.90	12.24	82.60
February	6.26	5.62	20.20	57.84	4.74	11.88	82.78
March	1.76	4.90	34.67	52.14	1.95	6.66	88.76
April	1.35	4.18	35.82	51.97	1.56	5.53	89.35
May	1.60	5.00	36.80	49.78	1.86	6.60	88.44
June	1.70	5.30	37.80	45.90	1.20	7.00	84.90
July	1.72	5.07	39.50	45.72	1.20	6.79	86.42
August	3.00	6.02	40.30	42.98	1.70	9.02	84.98
September	4.02	6.00	10.00	65.25	2.13	10.02	77.38
October	5.04	7.38	3.58	74.36	2.36	12.42	80.30
November	5.60	8.00	2.87	76.00	2.67	13.60	81.54
December	5.92	18.83	1.14	60.17	9.44	24.75	70.75
	Giza-102						
January	2.62	4.37	10.22	60.96	16.27	6.99	87.45
February	3.14	3.65	21.42	45.10	17.65	6.79	84.17
March	2.38	4.49	33.04	45.83	9.89	6.87	88.76
April	1.47	5.21	36.39	45.73	3.89	6.68	86.01
May	1.72	5.19	39.52	44.15	3.58	6.91	87.25
June	1.82	4.47	42.72	40.98	3.39	6.29	87.09
July	1.84	3.47	45.52	38.79	3.11	5.31	87.42
August	2.12	3.77	48.02	37.91	2.23	5.89	88.16
September	3.04	3.54	24.72	60.26	3.14	6.58	88.12
October	3.16	4.47	23.72	60.37	3.53	7.63	87.62
November	3.72	4.85	20.99	61.01	4.60	8.57	86.60
December	3.88	6.30	19.43	59.18	6.35	10.18	84.96

16:0; Palmitic acid, 18:0; Stearic acid, 18:1; Oleic acid, 18:2; Linoleic acid, 18:3; α-Linolenic acid, TSFA; Total Saturated Fatty Acids, TUFA; Total Unsaturated Fatty Acids.

The present results also, indicate that the interaction of Sakha-53 × April planting date recorded the highest value of total USFA (89.35%) followed by Giza-102 × March (88.76%). The highest value of oleic (48.02 %) were recorded from the interaction of Giza-102 × August planting date followed by Giza-102 × July (45.52%). The highest value of linoleic (ω_6) (76.00%) were obtained by the interaction of Sakha-53 × November planting date followed by Sakha-53 × October planting date (74.36%).

The interrelationships among sunflower traits

The correlation coefficients between seed yield fed^{-1} and other studied traits across 12 planting dates, 2 cultivars and 2 years are presented in Table (7). A highly significant and positive association was observed among seed yield fed^{-1} and seed yield plant^{-1} (0.87**), number of leaves plant^{-1} (0.83**), head diameter (0.75**) and 1000-seed weight (0.72**). These results are in agreement with those obtained by Abd El-Mohsen (2013), in Egypt, who indicated that seed yield plant^{-1}, head diameter and 1000-seed weight were the most important variables contributing towards higher seed yield ha^{-1}.

Table 7. Correlation coefficients among sunflower characters across 12 planting dates, 2 cultivars, and 2 years of 2013 and 2014.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
P2	-0.27									
P3	0.27	0.22								
P4	-0.47	0.66**	0.09							
P5	0.28	0.04	0.75**	0.00						
P6	-0.56	0.64**	-0.23	0.73**	-0.35					
P7	0.03	0.43**	0.09	0.52**	0.00	0.54**				
P8	-0.50	0.66**	0.25	0.85**	0.01	0.79**	0.68**			
P9	-0.69	0.59**	-0.29	0.63**	-0.30	0.71**	0.33	0.56		
P10	-0.46	0.51**	-0.01	0.83**	-0.28	0.75**	0.72**	0.87**	0.67**	
P11	-0.54	0.58**	-0.07	0.82**	-0.31	0.78**	0.68**	0.85**	0.79**	0.98**

P1; No. of days to maturity, P2; root length, P3; plant height, P4; No. leaves plant^{-1}, P5; leaf area index, P6; head diameter, P7; 1000-seed weight, P8; seed weight plant^{-1}, P9; seed-oil %, P10; seed yield fed^{-1}, P11; oil yield fed^{-1}.

CONCLUSION

Sunflower has a wide adaptability. It can be planted successfully from February up to August under the conditions of the newly reclaimed sandy soils in Egypt. This is a great opportunity, for increasing sunflower seed and oil production in Egypt and shortens the gap between oil production and consumption. Sakha-53 surpassed Giza-102 cultivar in all studied traits. Results indicated that increasing temperatures from March to August resulted in more oleic acid and less linoleic acid. Seed yield fed^{-1} is very closely and significantly related to seed weight plant^{-1}, number of leaves plant^{-1}, and less extent to head diameter.

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آداء محصول دوار الشمس المنزرع بالاراضي الرملية تحت مدي واسع من مواعيد الزراعة في مصر

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توفر الأراضي المستصلحة حديثا فرصة كبيرة لزيادة المساحة المخصصة لزراعة محاصيل البذور الزيتية في مصر. تمثلت أهداف هذا البحث في تحديد أفضل موعد و/أو مواعيد للزراعة التي تعطي أعلى محصول للبذور والزيت من وحدة المساحة الأرضية وتحديد الصنف المناسب تحت ظروف الاراضي الرملية بمنطقة وادي النطرون، مصر. وكذلك دراسة التغيرات في تركيب الزيت من الاحماض الدهنية خلال مواعيد الزراعة علي مدار العام. أجريت التجارب الحقلية في محطة التجارب الصحراوية التابعة لكلية الزراعة، جامعة القاهرة بمنطقة وادي النطرون- محافظة البحيرة، مصر تحت نظام الري بالتنقيط علي مدار العامين ٢٠١٣ و ٢٠١٤. حيث زُرع صنفي دوار الشمس سخا-٥٣ وجيزة-١٠٢ في أول كل شهر بدءاً من يناير حتى ديسمبر. أشارت النتائج الي إمكانية زراعة دوار الشمس من فبراير حتى أغسطس في الاراضي الرملية المستصلحة حديثاً. وقد أظهرت النتائج تفاوت محصول البذرة للفدان بشكل معنوي بين مواعيد الزراعة المختلفة. وتم الحصول على أعلى محصولي بذور وزيت للفدان من الزراعة في اول مارس (١٠٣٨.٣ و ٤٠٠.١ كجم/فدان)، يليه أبريل (٩١١.٧ و ٣٥٢.١ كجم/فدان). تفوق الصنف سخا-٥٣ علي الصنف جيزة-١٠٢ في جميع الصفات المدروسة. وبالاشارة الي تركيب الزيت من الاحماض الدهنية تشير النتائج الي أن زيادة درجات الحرارة خلال موسم النمو قد أدت الي زيادة الحامض الدهني الاوليك واجمالي الاحماض الدهنية غير المشبعة، وكذلك نقص الحامض الدهني اللينوليك واجمالي الاحماض الدهنية المشبعة. ارتبط محصول بذور الفدان معنوياً مع محصول النبات الفردي (r=0.87)، عدد أوراق النبات (r=0.83) وقطر القرص (r=0.75) .

Table 4. Mean squares of analysis of variance for all studied traits of sunflower cultivars under twelve planting dates (combined data of 2013 and 2014 years).

Source of variation	df	Days to maturity	Root length	Plant height	No. of leaves plant^{-1}	Leaf area index	Head diameter	1000 seeds weight	Seed weight plant^{-1}	Daily seed weight plant^{-1}	Seed oil content	Seed yield fed^{-1}	Oil yield fed^{-1}
Years(Y)	1	0.210	0.128	5.441	1.092	1.061	1.129	28.267	74.103	0.013	13.857	5206.946	2810.062
RY	4	0.720	5.114**	0.540	0.328	0.088	0.354	14.452**	12.660	0.002	0.478**	1944.475	325.417
Planting dates (P)	11	915.45**	60.89**	1786.42**	159.66**	71.11**	144.98**	327.91**	2967.19**	0.695**	117.28**	674275.10**	114104.70**
YP	11	4.964	1.878*	103.461**	5.031**	0.477**	2.180**	5.409**	55.357**	0.012**	0.051	8779.394**	1239.810**
Error (P)	44	2.192	0.924	16.683	1.817	0.138	0.883	1.678	5.462	0.001	0.102	3293.949	479.968
Cultivars(C)	1	1563.54**	147.97**	148.01**	142.29**	0.94**	111.04**	2352.25**	1399.38**	0.048**	36.96**	881184.27**	138822.07**
YC	1	4.168	2.127**	1.776**	2.465**	0.007**	0.879**	10.563**	0.012	0.0001	0.154	1534.091	187.599
PC	11	73.93	0.06	0.05	0.10	0.002	0.66	0.46	4.06	0.003	0.14	392.22	187.78
YPC	11	1.831	0.004	0.006	0.030	0.000	0.045	0.161	1.686**	0.001**	0.078	250.662	32.835
Error (C)		48	1.270	0.025	0.019 0.042	0.000	0.032	0.461	0.481	0.0001	0.057	1147.941	166.305
C.V (%)			1.4	1.2	0.1 1.1	0.29	1.1	1.3	1.5	2.09	0.68	4.9	5.2

*** and ** indicate significance at 5% and 1% probability level, respectively.**

Table 5. Means of studied traits of two sunflower cultivars under twelve planting dates (combined data of 2013 and 2014 years).

Treatment	Days to maturity	Root length (cm)	Plant height (cm)	Leaves $plant^{-1}$ (no)	Leaf area index	Head diameter (cm)	1000 seed weight (g)	Seed weight $plant^{-1}$ (g)	Daily seed weight $plant^{-1}$ (g)	Seed oil (%)	Seed yield fed^{-1} (kg)	Oil yield fed^{-1} (kg)
Planting date (P)												
January	86.5	11.0	137.6	10.8	4.0	10.6	48.3	26.5	0.307	30.9	316.2	97.9
February	85.0	10.9	145.5	21.2	5.6	16.0	59.2	62.1	0.731	29.9	868.2	260.3
March	76.8	15.9	150.7	22.6	6.2	17.4	60.3	70.7	0.920	38.5	1038.3	400.1
April	70.7	15.8	128.8	22.1	2.5	20.4	59.4	65.8	0.931	38.6	911.7	352.1
May	68.9	15.3	123.1	20.1	2.2	23.9	57.2	63.2	0.917	37.9	838.4	317.9
June	68.5	15.6	125.8	23.0	2.4	1 7.4	46.7	50.3	0.735	37.8	811.1	305.9
July	72.5	10.2	126.2	19.1	2.5	17.3	48.4	42.8	0.589	37.4	766.1	287.2
August	75.3	9.9	112.5	17.2	2.9	15.2	58.6	39.2	0.522	37.0	791.8	293.6
September	71.9	14.0	155.0	20.1	9.2	15.9	52.1	54.1	0.753	36.4	665.7	242.5
October	79.8	13.1	135.4	18.4	8.6	15.2	51.4	44.4	0.556	34.0	429.8	146.7
November	90.9	12.3	130.8	18.1	5.7	13.7	49.6	30.7	0.337	33.1	420.3	139.6
December	93.8	11.8	138.3	13.6	4.7	12.7	48.3	24.8	0.263	32.0	403.2	129.5
$L.S.D_{0.05}$ (P)	1.2	1.1	3.4	1.1	0.3	0.8	1.5	1.9	0.026	0.3	47.2	18.3
Cultivars (C)												
Sakha-53	81.7	14.0	135.2	19.9	4.8	17.2	57.3	51.0	0.648	35.8	766.6	278.8
Giza-102	75.1	11.9	133.1	17.9	4.6	15.4	49.2	44.8	0.612	34.8	610.2	216.7
F-test (C)	**	**	**	**	**	**	**	**	**	**	**	**

**** indicate significance at 1% probability level.**