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SOME AGRONOMIC FACTORS AFFECTING PRODUCTIVITY AND QUALITY OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) IN NEWLY CULTIVATED SANDY SOIL

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ABSTRACT

Six field experiments were carried out at the experimental farm, faculty of agriculture, Zagazig university, Khattara region, Sharkia governorate, Egypt during two successive summer seasons of 2006 and 2007 to study the effect of planting density, nitrogen fertilization levels and sowing dates on yield attributes, yield and seed quality of two sunflower cultivars.

The results indicated that delaying sowing date from April, 15th to May, 15th then to June, 15th significantly decreased plant height, head diameter, 100-seed weight, head seed density, weight of seeds / head, seed, oil and protein yields / fad. as well as seed oil content.

The results also revealed the superiority of Sakha-53 cv. in upper mentioned characters as compared with Giza-102 cv.

Wide spacing of 30 cm between hills (23,333 plants / fad.) appeared to produce the highest values of plant height, head diameter, 100-seed weight, head seed density, weight of seeds/head and seed oil content, while the dense planting of 35,000 plants / fad tended to produce higher seed, oil and protein yields / fad.

Increasing nitrogen fertilization levels from 60 to 90 then to 120 kg N/fad. significantly increased plant height, head diameter, 100-seed weight, head seed density, weight of seeds/head, seed, oil and protein yields/fad. as well as seed oil content.

Key words: Sunflower cultivars, plant density, nitrogen, sowing date, yield quality.

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INTRODUCTION

Sunflower is one of the essential oil crops in Egypt and all over the world, it contain about 35-50% oil, 20-25% protein and it is one of the most important crops which could be cultivated successfully in newly reclaimed sandy soils in Egypt.

Production of oil crops in Egypt is insufficient for local consumption. So, it is of great importance to improve sunflower production, which could be achieved by several agricultural practices, such as chosen the optimum sowing date, reaching the promising varieties, ideal planting density and sufficient nitrogen fertilization level.

Regarding the influence of sowing date, several investigators stated that, delaying sowing date of sunflower significantly decreased plant height, head diameter, 100-seed weight, seed and oil yields / fad (Sharief, 1998 and El-Sadek *et al.*, 2004). Furthermore, Abul-Naas *et al.* (2000) and Sharief *et al.* (2003) recorded significant decrease in weight of seeds / head with delaying planting date.

Yakout *et al.* (1992) found that delaying sowing date significantly decreased protein yield / fad.

Concerning sunflower cultivars, several investigators showed sunflower varietal differences in head diameter, weight of seeds / head, seed and oil yields / fad. El-Hawary and Keshta (1998) and Sharief *et al.* (2003).

Furthermore, Sarhan (1995) and Abd El-Rasool (2001) recorded significant differences between sunflower cultivars in plant height and seed oil content. However, Sarhan (1995), Abd El-Rasool (2001) and Sharief *et al.* (2003) showed significant differences in 100-seed weight. In addition, Yakout *et al.* (1992) and El-Saidy, Amal (2004) recorded significant differences in protein yield / fad between sunflower varieties.

Previous studies showed that widening hill spacing for sunflower plants significantly increased head diameter, 100-seed weight, weight of seeds / head and seed oil content (Basha, 2000; Bassal, 2003 and El-Mohandes *et al.*, 2005) as well as seed and oil yields / fad (Gewiefel *et al.*, 1997 and Basha, 2000). On the contrary, increasing planting density significantly increased seed and oil yields / fad (El-Mohandes *et. al.*, 2005). Furthermore, Basha (2000) and El-Mohandes *et al.* (2005) reported that widening hill spacing.

Significantly increased plant height. On the other hand,

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El-Naggar, Nehal (2007) recorded significant increase in plant height due to increasing planting density.

With respecting to N-fertilization levels, Abou Khadrah *et al.* (2000), Basha (2000) and El-Naggar, Nehal (2007) found that increasing nitrogen fertilization level up to 75, 90 and 120 kg N / fad significantly increased plant height, head diameter, 100-seed weight, weight of seeds / head, seed and oil yields / fad. However, El-Sadek *et al.* (2004) reported that increasing nitrogen fertilization level significantly decreased seed oil content of sunflower. While, El-Naggar, Nehal (2007) revealed significant increase in seed oil content due to increasing N-level from 30 up to 90 kg / fad and then decreased with increasing N-level to 120 kg / fad. However, El-Saidy, Amal (2004) recorded significant increase in protein yield due to increasing N-level.

MATERIALS AND METHODS

Six field experiments were carried out at the Experimental Farm, Faculty of Agriculture, Zagazig University, Khattara region, Sharkia Governorate, Egypt during two successive summer seasons of 2006 and 2007 to study the effect of planting density, N-levels and sowing dates on yield attributes, yield and seed quality of two sunflower (*Helianthus annuus* L.) cultivars.

Sunflower was preceded by faba bean in both seasons. Each sowing date conducted in a separate experiment. Each experiment included 18 treatments, which were the combinations of two sunflower cultivars, three hill spaces and three nitrogen fertilization levels as follows:

Sowing Dates

A– April, 15^{th} (early sowing).

B– May, 15^{th} (moderate sowing).

C- June, 15^{th} (late sowing).

Sunflower Cultivars

A- Sakha-53.

B- Giza-102.

Planting Density

A- 30 cm between hills to obtain 23,333 plants/fad.

B- 25 cm between hills to obtain 28,000 plants/fad.

C- 20 cm between hills to obtain 35,000 plants/fad.

Nitrogen Fertilization Levels

A- 60 kg N /fad
B- 90 kg N /fad

C- 120 kg N /fad

A split- split plot design with three replicates was used for each sowing experiment in both seasons, sunflower cultivars were assigned to the main plots. The sub plots included hill spaces, while nitrogen fertilization levels were randomly distributed in the sub-sub plots.

The sub-sub plot area was 10.8 m^2 included 6 rows of 3 m long and 60 cm apart .Calcium super phosphate (15.5% P_2O_5) at rate of 200 kg/fad was applied at seedbed preparation whereas, potassium sulphate (48% K_2O) at rate of 100kg/fad was added at two equal doses during seedbed preparation and after thinning.

Nitrogen fertilizer in form of ammonium sulphate (20.5% N) was added at four equal doses, after thinning i.e. three weeks from sowing, then each seven days. Twenty days after sowing, thinning to one plant / hill was made. Surface irrigation using underground water (around 850 ppm) was used. Where, irrigation was applied as it was needed by the crop (3-4 days intervals). The other cultural practices were applied as recommends. Harvest was done after 90 days from sowing.

The experimental soil was sandy in texture with a pH average of 8.1and organic matter of 0.28%. The available N, P and K contents of the upper 30 cm soil depth were 15.4, 3.4 and 91.7 ppm, respectively.

At harvest, five guarded plants were randomly taken from the third row of each experimental unit to determine the following characters:

1- Plant height “cm”.

2- Head diameter (cm).

3- Head seed density

$$= \frac{\text{No. of seeds/head}}{\text{Head area (cm}^2\text{)}} \quad (\text{seed / cm}^2)$$

4- 100-seed weight “g”.

5- Weight of seeds / head “g”.

The middle two rows of each sub-sub plot with area of 3.6 m^2 were harvested to determine seed yield “kg/fad”.

Sufficient amount of dried sunflower seeds were milled to fine powder. Then, constant samples of dried fine powder were used to determined oil and total nitrogen contents in sunflower seeds as described by A. O. A. C. (1980). Where, seed oil content

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determined using Soxhlet apparatus and extracted by petroleum ether (60- 80°C) for a period of 12 hours. Whereas, total nitrogen was determined using the modified micro Kjeldahl method. Total nitrogen was multiplied by 6.25 to obtain crude protein content. Thereafter, oil and crude protein yields/fad were calculated by multiplying their contents by seed yield/fad. Then, the following seed quality characters were recorded.

7- Seed oil content (%).

8- Oil yield “kg/fad”.

9- Protein yield “kg/fad”.

Analysis of variance and combined analysis for each season were carried out as described by Snedecor and Chochran (1981).

For comparison between means, Duncan's multiple range test was applied (Duncan, 1955), where means had the different letters were statistically significant, while those means followed by the same letter were statistically insignificant. In the interaction tables capital and small letters were used to compare between means in rows and columns, respectively.

RESULTS AND DISCUSSION

Plant Height “cm”

Data presented in Table 1 show the influence of planting density, nitrogen fertilization levels and sowing dates on plant height of two sunflower cultivars. Sakha-53 cv. appeared to produce longer plants than Giza-102 cv. during both seasons. These results were confirmed significantly or highly significantly where Sakha-53 cv. exceeded Giza-102 cv. by about 33.50% and 22.50% during both successive seasons, respectively. In this manner, Sarhan (1995) and El-Hawary and Keshta (1998) stated that sunflower varieties differed significantly in plant height.

The tried decrease in planting density from 35,000 to 28,000 and 23,333 plants / fad resulted in significant increase in plant height of sunflower plants. In other words, the present results exhibited a proportional increase in plant height of sunflower plants with the decrease in planting density at the range used herein. It seem that dense plants may be suffer from manual shading which lead to the predominance of invisible light radiation inside the crop canopy, in addition to the aggressive competition between plants for nutrition elements, water… etc under such circumstances. The obtained results are in agreement with those reported by Basha (2000) and El-Mohandes *et al.* (2005). On the contrary, El-Naggar, Nehal (2007) and Sedghi *et al.* (2008) showed that, dense planting tended to produce longer plants of sunflower.

Regarding the influence of N-fertilization on plant height of sunflower, the results revealed highly significant differences where increasing N-fertilization from 60 to 90 then to 120 kg / fad tended to be gradually increase plant height. Such positive response which was rather expected since vegetative growth of crop plants and nitrogen supply link can not be overlooks. So, plant height results followed the same patterns of vegetative growth and growth analysis measurements. These findings are in accordance with those reported by Abou Khadrah *et al.* (2000), Basha (2000) and El-Naggar, Nehal (2007).

Respecting the influence of sowing dates on plant height, the combined results revealed highly significant differences during both seasons, where plant height significantly decreased with delaying in sowing dates from April 15th to May 15th then to June 15th with no significant differences between May 15th and June 15th during the first season. Thus, the tallest plants of 101.69 and 105.63 cm were achieved by early sowing of April 15th during first and second seasons, respectively. Likely, these results followed the same patterns of vegetative growth which could be attributed to the given chance for plants of early sowing to receive higher heat summation, intercepted light and energy with prolonging the growth period which in turn on metabolic processes resulted in more and vigour vegetative growth. Similar results were reported by Sharief (1998), Abul-Naas *et al.* (2000) and El-Sadek *et al.* (2004).

Head Diameter "cm"

Data pertaining to varietal differences and the influence of planting density, nitrogen fertilization levels and sowing date on head diameter of sunflower during the two summer seasons are presented in Table 1. Highly significant differences were existed between sunflower cultivars during both seasons where Sakha-53 cv. gave larger head diameter than Giza 102 one.

Table 1. Plant height (cm), head diameter (cm), head seed density, 100-seed weight (g) and weight of seeds/head (g) of two sunflower cultivars as influenced by, planting density, nitrogen fertilization levels and sowing dates during two summer seasons of 2006 and 2007

Main effect and interaction	Plant height (cm)		Head diameter (cm)		Head seed density		100-seed weight (g)		Seed weight / head (g)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Cultivar (C):										
Sakha 53	110.83 a	97.89 a	13.67 a	11.06 a	3.71 a	3.81	4.59 a	4.00 b	22.23 a	14.98 a
Giza 102	83.02 b	79.91 b	11.32 b	9.16 b	3.32 b	3.62	4.35 b	4.57 a	14.90 b	10.55 b
F-test	**	**	**	**	**	N.S	**	**	**	*
Planting density (D):										
35,000 plants/fad	91.97 b	86.14 c	11.70 c	9.60 c	3.48 b	3.64	4.15 c	4.19 b	15.37 c	11.54 c
28,000 plants/fad	97.93 a	89.05 b	12.70 b	10.14 b	3.42 b	3.72	4.54 b	4.24 b	19.46 b	12.51 b
23,333 plants/fad	100.87 a	91.51 a	13.09 a	10.59 a	3.64 a	3.79	4.73 a	4.44 a	20.86 a	14.24 a
F-test	**	*	**	**	*	N.S	**	**	**	**
Nitrogen level (N):										
60 kg N/fad	93.19 c	83.63 c	12.06 c	9.51 c	3.49	3.89 a	4.28 c	4.17 b	16.80 c	11.75 b
90 kg N/fad	97.64 b	89.67 b	12.58 b	10.29 b	3.51	3.60 b	4.53 b	4.33 a	19.06 b	13.06 a
120 kg N/fad	99.95 a	93.40 a	12.84 a	10.53 a	3.54	3.66 b	4.61 a	4.36 a	19.83 a	13.49 a
F-test	**	**	**	**	N.S	**	**	**	**	**
Sowing date:										
April, 15th	101.69 a	105.63 a	14.30 a	12.42 a	3.51 b	3.28 b	5.37 a	4.86 a	24.34 a	18.81 a
May, 15th	93.58 b	93.33 b	12.50 b	10.04 b	2.80 c	3.41 b	3.70 c	4.32 b	14.45 c	11.51 b
June, 15th	95.56 b	67.74 c	10.69 c	7.87 c	4.23 a	4.46 a	4.34 b	3.68 c	16.90 b	7.98 c
F-test	**	**	**	**	**	**	**	**	**	**
Interactions:										
C x D	N.S	N.S	N.S	N.S	**	N.S	*	N.S	**	N.S
C x N	**	**	**	**	N.S	**	**	N.S	**	N.S
D x N	**	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S
C x D x N	N.S	N.S	N.S	N.S	N.S	N.S	**	N.S	N.S	N.S

The superiority of Sakha-53 cv. mostly attributed to genetical effects since it was obtained higher plant height and stem diameter values compared with those of Giza 102 cv. These results are in accordance with those reported by Sarhan (1995), El-Hawary and Keshta (1998) and Sherief *et al.* (2003).

Likely, planting density results revealed highly significant differences during both seasons where decreasing planting density from 35,000 to 28,000 then to 23,333 plants / fad tended to be significantly enlargement head diameter of sunflower gradually and consistently. Thus, the largest head diameter was achieved by light planting of 23,333 plants / fad while the smallest head diameter was recorded with the dense planting of 35,000 plants/fad. These results followed the same patterns of plant height. In this connection, Sarhan (1995) noticed that narrowing planting spaces from 40 to 30 and 20 cm apart caused a constant and significant decrease in head diameter of sunflower. Also, Sharief (1998) stated that head diameter of sunflower was significantly increased as planting density was decreased from 56 to 20 thousand plant/fad. In addition, similar results were reported by Bassal (2003), El-Mohandes *et al.* (2005) and Sedghi *et al.* (2008). However, Gewifel *et al.* (1997). indicated that planting density had no significant effects on head diameter of sunflower.

Increasing N-level from 60 to 90 and 120 kg/fad significantly increased head diameter. It is clear quite to notice that N-fertilization stimulated vegetative growth of sunflower plants which in turn resulted in enlargement of head diameter. Thus, the largest head diameter was achieved by the application of 120 kg N/fad, while the lowest diameter was given when low N-application of 60 kg/fad was applied. Several investigator reported similar results from them Abou-Khadrah *et al.* (2000), El-Sadek *et al.* (2004), Ibrahim *et al.* (2006) and El-Naggar, Nehal (2007).

Respecting the influence of sowing date on head diameter, the results indicated highly significant differences where delaying sowing date from April, 15th to May, 15th and June, 15th gradually decreased head diameter from 14.30 to 12.and 10.69 "cm" and from 12.42 to 10.04 and 7.87 cm during both seasons for the same followed order. Thus, the largest head

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diameter was achieved by early sowing of April, 15th, while the lowest head diameter was recorded with late sowing of June, 15th. These results followed the same patterns of plant height and stem diameter and in a completely agreement with those reported by Abul-Naas *et al.* (2000), Sharief *et al.* (2003) and El-Sadek *et al.* (2004).

Head Seed Density (seeds/cm^2)

Head seed density data which counted by dividing number of seeds/head by head area "cm^2" during both following seasons are presented in Table 1.

Meanwhile, sunflower varieties appeared to be highly significantly varied in the first season where Sakha-53 cv. gave higher dense seeds/head, while in the second season in spite of the superiority of the same cultivar (Sakha-53) compared with Giza 102 one, the differences could not reach the level of significance. The superiority of Sakha-53 cv. over Giza 102 cv. in head seed density reached around 0.39 and 0.19 seeds/cm^2 during both following seasons, respectively. Such results were expected since Sakha-53 cv. was given heavier and higher number of seeds/head as well as larger head diameter which in turn resulted in higher dense seeds/head as compared with Giza 102 cv. In addition, the results followed the same patterns of other yield attributes former presented and discussed through this investigation.

Likely, planting density results revealed significant differences in the first season, while in the second season insignificant differences were observed. Generally, light planting density of 23,333 plants / fad tended to produce higher seed dense/head which followed by middle density of 28,000 plants / fad, then the dense planting of 35,000 plants / fad recorded the lowest head seed density. These results followed the same patterns of head diameter, number of seeds/head and seed weight / head. Also, dense planting appeared to produce more empty seeds/head which resulted in reducing number of seeds/head and consequently lower head seed density as compared with lighter planting densities.

Concerning the influence of N-fertilization on head seed density, the results indicated highly significant differences in the second season, while it was insignificant in the first season. Meanthrough, the results in the second season show that the low application of N-fertilizer gave the highest head seed density as compared with higher N-applications. These results followed the reverse direction for other yield and growth attributes which indicate that such superiority achieved by low N-application in head seed density is not really and could be attributed to its smaller head diameter which resulted in higher head seed density.

Sowing dates appeared to be significantly affected head seed density during both successive seasons where the late sowing at June, 15th achieved the highest head seed density compared to early sowing dates in spite of the superiority of early sowing in both head diameter and number of seeds/head. Such increase in head seed density obtained by late sowing may be attribute to its smaller head diameter rather than the really superiority in this respect. Also, the results followed the reverse trend for other yield attributes.

Hundred Seed Weight (g)

The two sunflower cultivars differed significantly during both seasons Table 1 where Sakha-53 cv. gave heavier seeds in the first season in following to the same trends of former discussed yield attributes however in the second season the reverse direction was observed since Giza 102 cv. produced heavier seed compared with Sakha-53 cv. Although 100-seed weight variation mainly due to the genetic make up and the difference in genetic constitution, the environmental conditions may affect seed size and density to some how under certain stress conditions which may be explain such fluctuating in direction from season to another. Many investigators stated varietal differences in 100 or 1000 seed weight of sunflower varieties included Sarhan (1995), Abd El-Rasool, Samaa (2001) and Shareif *et al.* (2003).

Concerning the influence of planting density on 100 seed weight, the results indicated highly significant differences during both seasons where 100-seed weight tended to be gradually increased as planting density decreased from 35,000 to 28,000 and 23,333 plants /fad. Then, the light planting density obtained the heaviest seed weight which followed by middle density, while dense planting gave the lowest 100-seed weight, but the differences between middle and light planting densities did not reach the level of significance in the second season. The superiority of light planting density in 100-seed weight followed the same patterns of other yield attributes. These results are in accordance with those reported by Bassal (2003), El-Mohandes *et al.* (2005) and Sedghi *et al.* (2008). However, Yakout *et al.* (1992) and Geweifel *et al.* (1997) reported that planting density had no significant effects on 100-seed weight of sunflower.

Furthermore, N-fertilization results revealed highly significant differences during both growing seasons where increase N-fertilization level from 60 to 90 and 120 kg N/fad tended to be gradually increased 100-seed weight, but the differences between 90 and 120 kg N/fad levels did not reach the level of significance in the second season. These results followed the same patterns of other yield attributes which indicate that N-application enhanced all metabolic process in the plants that led to an increase in the dry matter accumulation and consequently 100-seed weight. Similar results were reported by several investigators from them El-Sadek *et al.* (2004), Ibrahim *et al.* (2006) and El-Naggar, Nehal (2007). However, El-Gendy *et al.*, (1992) indicated that N-fertilization level had no significant effects on 100-seed weight of sunflower.

Regarding the influence of sowing date on 100-seed weight, the results indicated highly significant differences during both seasons where delaying sowing date from April, 15th to May, 15th then to June, 15th gradually decreased 100-seed weight. In other words, early planting achieved the heaviest 100-seed weight followed by late sowing in the first season and mid-sowing in the second season. Then, the lowest 100-seed weight was achieved by mid sowing in the first season while it was recorded by late sowing in the second season. The superiority of early planting on mid and late sowing dates in 100-seed weight amounted to around 45.14; 23.73% and 12.50; 32.07% during first and second seasons, respectively. These results followed the same patterns of other yield attributes which all were given or existed higher values with early planting as compared with delay sowings. These results could be attributed to the effect of environmental conditions on sunflower plants during growing period of sowing dates which were more suitable and in favour of early sowing than later sowing dates. The results are in agreement with those reported by Sharief (1998), Abul-Naas *et al.* (2000) and El-Sadek *et al.* (2004).While, Asbage *et al.* (2009) reported that sowing dates had no significant effects on 100-seed weight of sunflower.

Seed Weight/Head (g)

Varietal difference results revealed significant and highly significant differences during both seasons Table 1 where Sakha-53 cv. outyielded Giza 102 cv. regarding seed weight/head. The superiority of Sakha-53 cv. over Giza 102 cv. amounted to about 49.20 and 41.99% during both seasons, respectively. These results were expected since Sakha-53 cv. was given higher yield attributes included head diameter, number of seeds/head and 100-seed weight. Thus, such difference could be attributed to the genetical variation and its interaction with environmental conditions which was in favour of Sakha-53 cv. The varietal differences effects were reported by several investigators included El-Hawary and Keshta (1998), Abd EL-Rasool, Samaa (2001) and Sharief *et al.* (2003).

Concerning the influence of planting density on seed weight/head, the results revealed highly significant differences during both seasons, where decreased planting density from 35,000 to 28,000 and 23,333 plants/ fad appeared to be gradually significantly increased seed weight/head in both seasons. In other words, light planting density outyielded both middle and dens plantings. The increment of seed weight/head achieved by light planting density over middle and dense plantings amounted to around 7.19; 35.72% and 13.83; 23.46% during both seasons in the same followed order. The results followed the same patterns of other yield attributes former exposed and discussed through this investigation. Similar results were reported by Basha (2000), Bassal (2003), El-Mohandes *et al.* (2005) and Sedghi *et al.* (2008). However, Geweifel *et al.* (1997) indicated that planting density had no significant effect on seed weight/head.

Likely, N-fertilization results indicated highly significant differences during both seasons where increasing N-fertilization level tended to improve the producing of seed weight/head. Then, the high N-level of 120 kg/fad gave the highest seed weight/head which followed by

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middle-level of 90 kg N/fad while, the low level of 60 kg N/fad recorded the lowest seed weight/head. But, the differences between middle and high N-levels did not reach the level of significance in the second season. The results followed the same patterns of other yield attributes which confirmed the stimulation effects of N-fertilization and its role in improvement yield productivity of sunflower crop. Several investigators reported similar results from them Abou Khadrah *et al.* (2000), Basha (2000), El-Sadek *et al.* (2004), Ibrahim *et al.* (2006) and El-Naggar, Nehal (2007).

Regarding the influence of sowing date on seed weight/head, the results indicated highly significant differences during both seasons where early sowing at April, 15th appeared to produce the highest seed weight/head during both growing seasons, while it was followed by late sowing in the first season and mid-sowing in the second season. Thus, the lowest seed weight/head of 14.45 "g" and 7.98 "g" were obtained by mid-sowing and late sowing during first and second seasons, respectively. However, the highest seed weight/head of 24.34 "g" and 18.81 "g" were achieved by early sowing during both seasons, respectively. The superiority of early sowing over mid and late sowings amounted to about 68.44; 44.02% and 63.42; 135.71% during both growing seasons in the same followed order regarding seed weight/head. The obtained results are in agreement with those reported by Sharief (1998), Abu-Naas *et al.* (2000) and Sharief *et al.* (2003).

The significant interaction effects between sunflower cultivars and planting densities during the first season Table 1-a showed that Sakha-53 cv. appeared to be obtained the highest seed weight/head (23.88 "g") when light planting density was applied, while the lowest one (13.66 "g") was recorded by Giza 102 cv. when dense planting was used. Also, the significant interaction between cultivars and N-fertilization levels during the first season (Table 1-b) indicates that the highest seed weight of 25.30 "g" was achieved by the same cultivar (Sakha-53) when 120 kg N/fad level was applied. On the other direction, the lowest seed weight/head of 12.61 "g" was obtained by Giza 102 cv. when the low nitrogen level of 60 kg/fad was applied.

Table 1-a. Seed weight / head (g) of sunflower as affected by the interaction between cultivars and planting density "combined data of three sowing dates for 2006 season"

Cultivars	Planting density (plants/ fad)		
	35,000	28,000	23,333
Sakha 53	B 19.94 a	A 22.87 a	A 23.88 a
Giza 102	B 13.66 b	A 15.25 b	A 15.78 b

Table 1-b. Seed weight/ head (g) of sunflower as affected by the interaction between cultivars and nitrogen levels "combined data of three sowing dates for 2006 season

Cultivars	Nitrogen level (kg/fad)		
	60	90	120
Sakha 53	C 18.12 a	B 23.27 a	A 25.30 a
Giza 102	C 12.61 b	B 15.66 b	A 16.42 b

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Seed Yield "kg/fad"

Varietal difference results indicate highly significant differences during both seasons Table 2, where Sakha-53 cv. outyielded Giza 102 cv.. These results followed the same patterns of all yield attributes included head diameter, number and weight of seeds/head and 100-seed weight which all stated the superiority of Sakha-53 cv. on the other cultivar. This superiority amounted to around 50.60 and 44.50% during first and second seasons, respectively. These results may be attribute to the differences among both studied cultivars in growth habit and response of each one to the environmental conditions during the growing seasons which controlled by genetical factors. Such responses reflect on growth characteristic and consequently yield attributes and ultimately seed yield per unit area. Several investigators showed such great differences among sunflower cultivars and genotypes regarding seed yield per unit area included El-Hawary and Keshta (1998), Abd El-Rasool (2001), Sharief *et al*. (2003) and Acko (2008). Seed yield usually declines significantly as planting density decreased due to rapid reduction in number of heads per unit area. In addition, seed yield decreases at higher planting density due to the reduction in the contribution of number of seeds/head as well as seed weight. Between these two extremes there is a large platueau area where seed yield changes slowly relative to planting density. Hence, seed yield/fad appeared to be gradually decreased as planting density decreased from 35,000 to 28,000 and 23,333 plants / fad. These results were confirmed highly significantly during both growing seasons with no significant difference between mid and dense planting densities in the first season. Meanwhile, the general means of seed yield/fad of both growing seasons for dense, middle and light panting densities were 433.24, 411.74 and 371.47 kg/fad for the same followed order. Then, the dense planting exceeded middle and light planting densities in seed yield/fad by 5.22 and 16.63%, respectively. Similar results were reported by Yakout *et al*. (1992) and El-Mohandes *et al.* (2005). On the contrary, the reverse direction was observed by Geweifel *et al.* (1997), Basha (2000) and El-Naggar, Nehal (2007). However, Bassal (2003) indicated that middle planting density appeared to produce the highest sunflower seed yield per unit area.

Table 2. **Seed yield (kg / fad), seed oil content (%), oil yield (kg / fad) and protein yield (kg / fad) of two sunflower cultivars as influenced by, planting density, nitrogen fertilization levels and sowing dates during two summer seasons of 2006 and 2007**

Main effect and interaction	Seed yield (kg/fad)		Seed oil content (%)		Oil yield (kg/fad		Protein yield (kg/fad)	
	2006	2007	2006	2007	2006	2007	2006	2007
Cultivar (C):								
Sakha 53	566.97 a	400.98 a	36.52 a	35.94 a	208.32 a	145.89 a	133.07 a	91.42 a
Giza 102	376.47 b	277.51 b	34.95	34.05 b	132.53 b	95.03 b	86.87 b	62.14 b
F-test	**	**	*	**	**	**	**	**
Planting density (D):								
35,000 plants/fad	488.56 a	377.91 a	35.40 b	33.86 b	175.39 a	130.79 a	110.01 ab	82.10 a
28,000 plants/fad	488.91 a	334.57 b	35.72 b	35.42 a	176.24 a	120.11 b	114.46 a	77.78 a
23,333 plants/fad	437.68 b	305.26 c	36.08 a	35.71 a	159.65 b	110.47 c	105.44 b	70.46 b
F-test	**	**	**	**	**	**	**	**
Nitrogen level (N):								
60 kg N/fad	429.98 c	311.60 c	34.74 c	34.32	151.22 c	108.28 c	95.36 c	66.77 c
90 kg N/fad	482.46 b	344.42 b	36.09 b	35.47	175.88 b	123.82 b	115.15 b	79.01 b
120 kg N/fad	502.72 a	361.72 a	36.37 a	35.21	184.17 a	129.27 a	119.40 a	84.57 a
F-test	**	**	**	N.S	**	**	**	**
Sowing date:								
April, 15th	652.27 a	506.49 a	37.24 a	36.33 a	242.66 a	184.99 a	146.87 a	112.96 a
May, 15th	365.43 b	301.54 b	35.48 b	35.06 a	130.41 b	106.02 b	86.76 b	68.52 b
June, 15th	397.45 b	209.70 c	34.48 c	33.60 b	138.21 b	70.37 c	96.27 b	48.87 c
F-test	**	**	**	**	**	**	**	**
Interactions:								
C x D	N.S	N.S	N.S	N.S	*	N.S	**	N.S
C x N	**	N.S	N.S	N.S	**	N.S	**	N.S
D x N	**	N.S	N.S	N.S	**	N.S	N.S	N.S
C x D x N	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Concerning the influence of N-fertilization on seed yield/fad, the results indicated highly significant differences through both growing seasons where increasing N-level from 60 to 90 and 120 kg/fad gradually and significantly increased seed yield/fad. These results followed the same patterns of yield attributes formerly discussed in this investigation. The relative increases in seed yield/fad due to increasing N-level from 60 to 90 and 120 kg/fad were about 12.21; 16.92% and 10.53; 16.08% during both growing seasons for the same followed order. Such results could be attributed to the promotion effect of nitrogen on vegetative growth which in turn favoured metabolic processes and increased plant height, head diameter and subsequently increased the all yield attributes as mension before. The positive response of seeds yield of sunflower to N-fertilization was noticed by several investigators in the literature from them Basha (2000), El-Sadek *et al.* (2004), Ibrahim *et al.* (2006) and El-Naggar, Nehal (2007).

Likely, sowing date results revealed highly significant differences during both growing seasons where delaying sowing date tended to be significantly decreased seed yield/fad with no significant differences between May, 15th and June 15th in the first season. In other words, seed yield/fad was decreased with delay in planting from April, 15th to May, 15th and June, 15th. In comparing April, 15th planting with May, 15th and June, 15th plantings, the reduction in seed yield/fad reached around 78.79; 64.11% and 67.97; 141.53% during both growing seasons in the same followed order. From reviewing the previous results on the basis of seed yield and its components, it could be concluded that early planting of April, 15 was the most favourable date for planting sunflowerundersuch circumstances. In addition, the increase in growth characters due to early planting may be attribute to the environmental conditions during this period which seem to be suitable for leaf emergence and sequentially increased dry matter accumulation that reflected increases in seed number and weight which resulted in increases of seed yield per feddan. The results are in accordance with those reported by Sharief (1998), Abul-Naas *et al.* (2000), El-Sadek *et al.* (2004) and Asbag *et al.* (2009).

The significant interaction effects between sunflower cultivars and N-levels during the first season (Table 2-a) showed that Sakha-53 cv. surpassed Giza 102 cv. under different N-levels. Also, high N-level of 120 kg/fad gave higher seed yield/fad for both sunflower cultivars. Therefore, the highest seed yield/fad (602.47 kg) was achieved by Sakha-53 cv. when 120 kg N/fad was applied. While the lowest seed yield/fad (348.48 kg) was obtained by Giza 102 cv. when low N-level of 60 kg/fad was added. Furthermore, the significant interactions between planting densities and N-levels during the first season, Table 2-b indicate that dense planting gave higher seed yield/fad under different N-levels and likely high N-level of 120 kg/fad gave higher seed yield/fad under different planting densities. Thus, the highest seed yield of 403.26 kg/fad was given by dense planting when 120 kg N/fad was applied. On the other hand, the lowest seed yield/fad of 281.14 kg/fad was obtained by light planting when low N-level of 60 kg/fad was applied.

Seed Oil Content (%)

Date presented in Table 2 show the changes in seed oil percentage of sunflower due to varietal differences, planting densities, N-fertilization level and sowing dates during two growing seasons.

Regarding sunflower cultivars, the results showed significant and highly significant differences during both seasons when Sakha-53 cv. had higher seed oil percentages as compared with Giza 102 cv. It is obvious that Sakha-53 cv. surpassed Giza 102 one by 1.57% and 1.89% during the two summer seasons, respectively. This increase in seed oil percentage associated with Sakha-53 cultivar might be attributed to the superiority of its capability in transformation of sugar to fat in the seed tissue than the other cultivar. Also, several investigators indicated the significant differences among sunflower cultivars in seed oil content included El-Hawary and Keshta (1998), Basha (2000) and Acko (2008). Respecting the influence of planting density on seed oil content, the results revealed highly significant differences during both seasons where seed oil content tended to be gradually increased as planting density decreased from 35,000 to 28,000 and 23,333 plant/fad. But, no significant differences were detected between dense and middle-

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Table 2-a. Seed yield (kg/fad) of sunflower as affected by the interaction between cultivars and nitrogen levels "combined data of three sowing dates for 2006 season

Cultivars	Nitrogen levels (kg/fad)		
	60	90	120
Sakha 53	C 511.47 a	B 586.97 a	A 602.47 a
Giza 102	C 348.48 b	B 377.96 b	A 402.97 b

Table 2-b. Seed yield (kg/fad) of sunflower as affected by the interaction between planting density and nitrogen levels "combined data of three sowing dates for 2006 season

Planting density (plants / fad)	Nitrogen levels (kg/fad)		
	60	90	120
35,000	C 349.07 a	B 381.40 a	A 403.26 a
28,000	B 304.58 b	A 343.33 b	A 355.79 b
23,333	C 281.14 c	B 308.53 c	A 326.11 c

planting densities in the first season and between middle and light – densities in the second season.

Generally, light planting density gave higher seed oil percentages while dense planting recorded lower seed oil percentages during both seasons. This may be due to the sufficient of nutrition elements, CO_2 and light which increased assimilation rate and oil formation. In this connection, Basha (2000) reported that the content of sunflower seeds from oil significantly increased by increasing the hill spacing from 20 to 30 cm. Also, El-Mohandes *et al.* (2005) found that low population of sunflower plants produced the highest values of seed oil content as compared with the high one. The obtained results are in agreement with those reported by Geweifel *et al.* (1997) and Bssal (2003). On the contrary Sharief (1998) reported that increasing plant population density from 28,000 up to 56,000 plant/fed significantly increased seed oil percentage.

Concerning the influence of N-fertilizer level on seed oil content, the results indicated highly significant differences in the first season where the additional application of N-fertilization level was accompanied by a gradual increase in this criteria however, in the second season no significant differences was detected between N-fertilization levels in this respect. In this manner, El-Naggar, Nehal (2007) reported that seed oil content of sunflower tended to be significantly increased as N-fertilizer level was increased from 30 to 90 kg N/fad. However, El-Gendy *et al*. (1992) indicated that N-fertilization level had no significant effects on seed oil content of sunflower. Otherwise, Abou Khadrah *et al.* (2000) and El-Sadek *et al.* (2004) showed that seed oil content of sunflower tended to be decreased as N-level was increased.

Sowing date results revealed highly significant differences during both seasons where seed oil content appeared to be gradually decreased as sowing date was delayed from April to May and June. Then, the highest seed oil percentages of 37.24 and 36.33% were achieved by early sowing (April, 15^{th}) during the first and second seasons, respectively. Otherwise, the lowest seed oil percentages of 34.48 and 33.60% were recorded by the late sowing of June, 15^{th} during both seasons, respectively. The increase of seed

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oil content by sowing sunflower early may be due to environmental conditions in this period which seems to be suitable for translocation the nutrient elements to seed which in turn increase fatty acids and consequently oil seed percentage. These results are in general agreement with those reported by Sharief (1998), Abul-Naas *et al.* (2000) and El-Sadek *et al.* (2004), who found that oil percentage was relatively constant with early sowing but decreased by late one. However, Yakout *et al.* (1992) indicated that seed oil percentage of sunflower was significantly increased as sowing date was delayed.

Oil Yield (kg/fad)

Data pertaining to the influence of varietal differences, planting density, N-fertilizer level and sowing date on oil yield / fad during the two seasons are presented in Table 2.

Varietal difference results revealed highly significant differences during both seasons where Sakha-53 cv. produced higher oil yield than Giza 102 one. The relative increase in oil yield achieved by Sakha-53 cv. amounted to around 57.19 and 53.52% during first and second seasons, respectively. The superiority of Sakha-53 cv. in oil yield could be attributed to its increases in both seed yield and oil percentage. Many investigators came to the same conclusion such as El-Hawary and Keshta (1998), Basha (2000) and Sharief *et al.* (2003). Then, Sakha-53 cv. could be recommended to be cultivated at Sharkia area or other like and under such circumstances area for its maximum and high oil yield.

Regarding the influence of planting density, the results revealed highly significant differences when dense planting tended to produce higher oil yield /fad followed by mid-planting density while, light planting density produced the lowest oil yield /fad. Such trend was confirmed significantly during the second season while no significant differences were observed between dense and mid-planting densities in the first season. The relative decrease in oil yield/fad caused by light planting density as compared with dense and mid-planting densities reached about 9.86%; 10.39% and 18.39; 8.73% during both growing seasons for the same following order. These results followed the same patterns of seed yield which confirmed the superiority of dense planting in producing higher seed yield /fad which in turn produced higher oil yield/fad as compared with lower planting densities. Then, the increase in oil yield / fad from dense planting mainly due to its superiority in producing higher seed yield/fad rather than the differences in seed oil percentage which followed the reverse direction. These results are in conformity with the findings reported by Sharief (1998) and El-Mohandes *et al.* (2005). On the contrary, Geweifel *et al.* (1997), Basha (2000), and El-Naggar, Nehal (2007) showed that oil yield per unit area tended to be significantly decreased as planting density increased. However, Bassal (2003) reported that mid-planting density produced higher oil yield per unit area as compared with either light or dens plantings.

Concerning the effect of N-fertilizer levels on oil yield /fad, the results indicated highly significant differences where, increasing N-fertilizer level from 60 to 90 and 120 kg/fad tended to be gradually increased oil yield/fad. In other words, high N-level of 120 kg/fad produced the highest oil yield/fad which followed by the middle N-dose of 90 kg/fad, while the low N-level of 60 kg/fad produced the lowest oil yield/fad. The relative increase in oil yield/fad achieved by the application of 120 kg N/fad compared to the application of 60 and 90 kg N/fad levels amounted to 21.79; 4.71% and 19.39; 4.40% during first and second seasons, respectively. These results followed the same patterns of yield and yield attributes as well as seed oil percentage. Then, it could be concluded that such increase in oil yield/fad resulted from the increase in N-fertilizer mainly due to its superiority in producing higher seed yield/ fad and seed oil content. Several investigators came to the same conclusion from them Basha (2000), El-Sadek *et al.* (2004), Ibrahim *et al.* (2006), and El-Naggar, Nehal (2007).

Concerning the influence of sowing date on oil yield/fad, the combined data revealed highly significant differences when early sowing at April, 15th appeared to be produced the highest oil yield/fad during first (242.66 kg/fad) and second (184.99 kg/fad) seasons. Meanwhile, delaying sowing date tended to be significantly decreased oil yield/fad. Thus, the lowest oil yield/fad (70.37 kg/fad) was

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produced by the late sowing of Jun, 15th in the second season, while no significant difference was detected between mid and late sowing dates in the first season. Generally, the results followed the same patterns of yield and yield attributes as well as seed oil percentage which all confirmed the superiority of early sowing in producing higher seed yield/fad and higher seed oil percentage as compared with either mid or late sowing dates which resulted in producing higher oil yield/fad. The results are in a full agreement with those reported by Abul-Naas *et al.* (2000), Sharief *et al.* (2003) and El-Sadek *et al.* (2004).

Finally, the significant interaction between the studied factors on oil yield/fad during the first season indicated that Sakha-53 cv. produced the highest oil yield (217.76 kg/fad) when middle-planting density was applied, while the lowest oil yield/fad (119.34 kg/fad) was given by Giza 102 cv. when light planting density was applied (Table 2-c). Furthermore, the significant interaction between sunflower cultivars and N-fertilizer levels (Table 2-d) showed that Sakha-53 cv. produced the highest oil yield/fad (224.84 kg/fad) when the high N-level of 120 kg/fad was applied. On the other side, the lowest oil yield/fad (119.47 kg/fad) was produced by Giza 102 cv. when low N-level of 60 kg/fad was added.

Moreover, the significant interaction between planting density and N-fertilizer level during the second season (Table 2-e) indicated that dense planting tended to produce higher oil yield/fad under different N-levels. Thus, the highest oil yield/fad (192.89 kg/fad) was achieved by dense planting when 120 kg N/fad was added. However, the lowest oil yield/fad (143.28 kg/fad) was obtained by light planting density when low N-level of 60 kg/fad was applied.

Protein Yield (kg/fad)

Regarding varietal differences, (Table 2), the results indicated highly significant differences in both seasons where Sakha-53 cv. outyielded Giza 102 one by amount 53.18 and 47.12% during the two seasons, respectively. The superiority of Sakha 53 cv. In producing protein yield/fad might be mainly due to its ability to produce higher seed yield/fad in addition to yield attributes evaluated as compared with Giza 102 cv.

Table 2-c. Oil yield (kg/fad) of sunflower as affected by the interaction between cultivars and Planting density "combined data of three sowing dates for 2006 season

Cultivars	Planting density (plants/ fad)		
	35,000	28,000	23,333
Sakha 53	B 207.22 a	A 217.76 a	B 199.97 a
Giza 102	A 143.55 b	A 134.71 b	B 119.34 b

Table 2-d. Oil yield (kg / fad) of sunflower as affected by the interaction between cultivars and nitrogen levels "combined data of three sowing dates for 2006 season

Cultivars	Nitrogen level (kg/fad)		
	60	90	120
Sakha 53	C 182.97 a	B 217.14 a	A 224.84 a
Giza 102	C 119.47 b	B 134.63 b	A 143.50 b

Table 2-e. Oil yield (kg / fad) of sunflower as affected by the interaction between planting density and nitrogen levels "combined data of three sowing dates for 2007 season

Planting density (plants / fad)	Nitrogen levels (kg/fad)		
	60	90	120
35,000	C 152.23 a	B 181.04 a	A 192.89 a
28,000	C 158.16 b	B 181.32 a	A 189.22 a
23,333	C 143.28 c	B 165.29 b	A 170.39 b

Furthermore, these results followed the same patterns of seed yield/fad. Generally, the varietal differences in protein yield mostly due to their genetic make up and their differences in seed yields/plant and per unit area as well as crude protein percentage in seeds. These results are in accordance with those reported by Yakout *et al.* (1992) and El-Saidy, Amal (2004).

Concerning the influence of planting density on protein yield/fad, the results indicated highly significant differences during both seasons. Meanthrough, dense and mid-plantings of 35,000 and 28,000 plant/fad appeared to produce higher protein yield/fad as compared with lighter planting of 23,333 plants / fad. These results almost followed the same patterns of seed yield/fad. Then, it could be conclude that protein yield/fad was a function of seed yield/fad rather than seed protein content.

Likely, N-fertilization level results revealed highly significant differences during the two seasons where increasing N-level from 60 to 90 and 120 kg/fad gradually increased protein yield during both seasons. The relative increase of protein yield with increasing N-level from 60 to 90 and 120 kg/fad amounted to 20.69; 25.21% and 18.33; 26.66% during first and second seasons, respectively. Similar results were reported by El-Saidy, Amal (2004).

With respecting to the influence of sowing dates on protein yield, the results revealed highly significant differences where, protein yield decreased consistently as sowing was delayed from April to June, while no significant differences were detected between May and June sowings in the first season. Then, the early sowing of April produced the highest protein yield which surpassed May and June sowings by 69.28; 52.56% and 64.86; 131.14% during first and second seasons, respectively. These results followed the same patterns of seed yield/fad as well as all yield attributes. The obtained results are in a good line with those reported by Yakout *et al.* (1992).

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بعض العوامل الزراعية المؤثرة على إنتاجية وجودة محصول عباد الشمس فى الأراضى الرملية حديثة الاستزراع

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أقيمت ست تجارب حقلية بمزرعة كلية الزراعة-جامعة الزقازيق بمنطقة الخطارة-محافظة الشرقية خلال موسمى ٢٠٠٦و٢٠٠٧ بهدف دراسة تأثير كثافة الزراعة (٢٣٣٣٣، ٢٨٠٠٠ و ٣٥٠٠٠ نبات / فدان)، ثلاثة مستويات من السماد النيتروجينى (٦٠، ٩٠، ١٢٠كجم ن/فدان) وثلاثة مواعيد للزراعة (١٥ أبريل، ١٥ مايو، ١٥ يونيو) على إنتاجية وجودة صنفين من عباد الشمس (سخا ٥٣، جيزة ١٠٢) تحت ظروف الأراضى الرملية حديثة الاستزراع، ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

١- أدى تأخير ميعاد الزراعة من منتصف أبريل إلى منتصف مايو ثم إلى منتصف يونيو إلى حدوث إنخفاض معنوى فى كل الصفات تحت الدراسة (ارتفاع النبات، قطر القرص، كثافة البذور بالقرص، وزن الـ١٠٠ بذرة، وزن بذور القرص، محصول البذور، الزيت، البروتين/ف وكذلك نسبة الزيت بالبذور).

٢- تفوق الصنف سخا ٥٣ على الصنف جيزة ١٠٢ فى كل الصفات تحت الدراسة (ارتفاع النبات، قطر القرص، كثافة البذور بالقرص، وزن الـ١٠٠ بذرة، وزن بذور القرص، محصول البذور، الزيت، البروتين/فدان وكذلك نسبة الزيت بالبذور).

٣- أدت زيادة الكثافة النباتية من ٢٣٣٣٣ إلى ٢٨٠٠٠ ثم إلى ٣٥٠٠٠ نبات / ف إلى حدوث انخفاض معنوى فى صفات ارتفاع النبات، قطر القرص، كثافة البذور بالقرص، وزن الـ١٠٠ بذرة، وزن بذور القرص، نسبة الزيت بالبذور بينما ارتفع محصول البذور، الزيت، البروتين/فدان بزيادة الكثافة النباتية.

٤- أدت زيادة مستوى التسميد النيتروجينى من ٦٠ إلى ٩٠ وحتى ١٢٠ كجم ن / فدان إلى زيادة معنوية فى صفات ارتفاع النبات، قطر القرص، وزن الـ١٠٠ بذرة، وزن بذور القرص، محصول البذور، الزيت، البروتين / فدان وكذلك نسبة الزيت بالبذور.

٥- أظهرت نتائج تداخل الفعل المعنوى بين عوامل الدراسة ما يلى:

- تفوق الصنف سخا ٥٣ فى صفة محصول البذور / فدان عند الزراعة بالكثافة الأكبر (٣٥٠٠٠ نبات / فدان) والتسميد بالمستوى الأعلى من النيتروجين (١٢٠كجم ن/فدان).

- الحصول على أعلى محصول زيت لصنفى الدراسة عند الزراعة بالكثافة من ٢٨٠٠٠-٣٥٠٠٠ نبات / فدان والتسميد بمستوى ١٢٠ كجم ن / فدان.

٦- من خلال نتائج هذه الدراسة يمكن التوصية بزراعة الصنف سخا ٥٣ من عباد الشمس تحت ظروف الأراضى الرملية بمحافظة الشرقية بكثافة نباتية من ٢٨٠٠٠إلى ٣٥٠٠٠ نبات / فدان والتسميد النيتروجينى بمعدل ١٢٠ كجم ن / فدان.