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ANALYTICAL GROWTH AND SEED YIELD AS AFFECTED BY IRRIGATION LEVELS ON SOME SUNFLOWER GENOTYPES AND CULTIVARS UNDER SANDY SOIL CONDITIONS

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ABSTRACT

Water is critical factor affecting plant growth and development, where its time and quantity of application plays an important role in increasing the yield levels with saving water, especially in sandy soil with low water holding capacity. Optimum irrigation level would help in improving the economic yield as well as water use efficiency. Sunflower (*Helianthus annuus*, L.) is one of these plants that affected by water supply according to its huge vegetative growth and transpiration area. It is essential edible oil in many countries all over the world, which ranks the fourth position next to groundnut, soybean and rapeseed. So, this study aimed to investigate the effect of four levels of irrigation (I_1=1.2, I_2=0.9, I_3=0.6, I_4=0.3 $m^3 day^{-1}$/plot area) and five sunflower genotypes(G_1=P.L120, G_2=P.L125, G_3=P.L240, G_4=P.L770 and G5=P.L990) and two cultivars Sakha-53, Giza-102under North Sinai conditions during 2016 and 2017 seasons. In this study, there were 28 treatments (4 x 7). The Results indicated that seed head weight gave the highest values (100.00&109.00 g)and obtained from $I_3 \times G_4$ at both seasons.However,100 seed weight were 10.66 and 10.67 g and obtained from $I_1 \times G_4$ and I_2×sakha 53 at 2016 while, at the second season the values 11.00 g and obtained from $I_1 \times G_4$, $I_2 \times G_5$, $I_3 \times G_3$,G_4 and Giza 102, I_4×Giza 102.

INTRODUCTION

Sunflower (*Helianthus annuus,* L.) plays an important role in overcoming the oil gap between demand and supply in Egypt, where seeds oil content ranged between 40 to 45%. Also, its oil is rich in unsaturated fatty acid (oleic, linoleic, linolenic acids) which is potential for health benefits, meanwhile linoleic acid is found in 60% sunflower oil and this ratio reduces cholesterol in human blood **(Turhan *et al.*, 2010).** The total cultivated area of sunflower at the level of Arab Republic of Egypt for the season 2017 was 16139 fed., where, 8850 fed. are ancient lands and 7289 in new reclaimed ones. Its productivity was 16.000 ton fed^{-1}. The consumption ratio is 2.600 million ton while, the import reaches to 2.80 million ton in 2017 **(Abd El-satar *et al.*, 2017)**. **Hamza and Safina (2015)** determined that head diameter, 1000-seed weight, seed weight plant^{-1} were superior for Sakha-53 cv. in all studied characters as compared to Giza 102.Positive relationships were found among sunflower genotypes for seed yield, leaf area index, head diameter and 1000-achene weight (**Sharief and Said, 1993**); seed yield plant^{-1}, 1000- seed weight and head diameter (**Abd El-Mohsen, 2013). El-Sarag (2007)**found that the superiority of most of the studied characters were recorded by Sakha-53 cultivar under North Sinai environmental conditions. However,

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correlation between the main growth analysis criteria was positive with the seed yield per plant and plot (**Yankov and Tahsin, 2016).** Also**, Abd El-Satar *et al.* (2017)** illustrated that Sakha-53 cultivar ranked the highest studied characters among the other genotypes (Giza-102; promising line of L120).

In new reclaimed arid and semi-arid lands, water is the most important limiting factor for crop production (**Ashrafi and Razmjoo, 2009**), which decrease crop growth and also reduce from 40 to 60 percent of potential yield as affected by drought stress (**Reddy *et al*., 2004**). Adequate irrigation supply is considered as an essential factor that affect the accumulation of dry matter in the plant, as well as, vegetative growth of most crops (**Aminifar *et al*., 2012**). When early vegetative growth periods severe water deficits, it result in reducing plant height, leaf area and growth analysis criteria but may increase root depth, so, available water supply during that periods reflected on seed formation (**Doorenbos and Kassam, 1979; Beyazgul *et al*., 2000; Ali and Shui, 2009**). According to **Casadebaig *et al.* (2008),** minimization of water loss in response to water deficit is a major aspect of drought tolerance and can be achieved through the lowering of either leaf area expansion rate or transpiration per unit leaf area (stomata conductance). Although sunflower is known to be a drought tolerant crop or grown under dry land conditions, substantial yield increases can be achieved by supplementary irrigation, which is one of the most effective strategies to mitigate the effects of dry spells in crop production (**Fox and Rockstrom, 2000; ELSarag, 2007; Xiao *et al*., 2007; Saeed *et al*., 2015).**

So, this study aimed to evaluate some sunflower cultivars and genotypes in concern to growth analysis and seed yield as affected by adequate water supply in specific growth stages.

MATERIALS AND METHODS

Site Description

This research was conducted at the Experimental Farm of El-Arish Agriculture Research Station, Agriculture Research Center, North Sinai Governorate (31° 07` 13``N, 33° 49` 04`` E), during two successive summer seasons of 2016 and 2017. It aims to assess the effect of irrigation levels on some sunflower genotypes under North Sinai conditions with sandy soil texture. Seeds were obtained from Oil Crops Research Section, ARC, Giza, Egypt. This assessment included growth analysis characters, yield and yield attributes.

Treatments

This investigation included 28 treatments as a combination of 4 irrigation levels x 7 genotypes of sunflower. The treatments arranged as recommended for experimental design of randomized complete block design (RCBD) in split- plots with three replications. The main plots were randomly occupied by the four irrigation treatments *i,e* 25, 50, 75, and 100% of sunflower requirements ($25M^3day^{-1}fed^{-1}$), so, (I_1=1.2, I_2=0.9, I_3=0.6, I_4=0.3 m^3day^{-1}/plot area), where the sub plots were occupied with two cultivars Sakha 53 and Giza 102 and five genotypes (G_1=P.L120, G_2=P.L125, G_3= P.L240, G_4=P.L770, G_5= P. L990).

Agricultural Practices

Organic fertilization (150 kg fed^{-1}) and superphosphate (15.5% kg P_2O_5) were applied during soil preparation. Ammonium nitrate (33.5% N) was the source of nitrogen fertilization in both seasons. Nitrogen fertilizer was divided into five doses after (18, 23, 28, 33 and 38 days) from sowing, respectively. Potassium sulfates (48% kg K_2O) at rate of 50 kg fed^{-1}, was added in two equal doses, the first dose was done after thinning, the second was added after 23 days from planting with the second dose of nitrogen fertilizer. All of the other agriculture practices were carried out as recommended for sunflower growing under the conditions of North Sinai. Drip irrigation system was used. Salinity of water was 6400 ppm. The length of irrigation lines was 13.5 m and distance between lines was 1 m apart and within lines was 0.25 so, plot area (13.5× 14.5) =195.75 m^2 according to irrigation treatment (56 line) experimental area was 783 m^2. The planting date was 30th June in 2016 and 2017 seasons, respectively. Harvesting date were after 85 days.

Recorded Data

Samples of ten guarded plants from each experimental unit were selected randomly by taking off after 60 days from sowing to determine the growth analysis criteria; Shoot/Root weight ratio (Sh/Rw R), Shoot/ Root length ratio (Sh/Rl R), Leaf area (dm^2/plant) and Leaf area index (LAI). At the end of complete flowering of heads, the heads of the two inner rows were bagged at early seed development for avoiding bird damages and used for estimating the yield and it′s components (after 85 days). Yield per feddan (ton fed^{-1}) were computed according to seed yield per plant and plot (g).

Statistical Analysis

The data were statistically analyzed according to **Snedecor and Cochran (1990)** using MSTAT computer program V.4 (1986). The means values were compared at 0.05 level of probability using Duncan's Multiple Range Test (DMRT) according to **Duncan (1955)**.

RESULTS AND DISCUSSION

Growth Analysis

Effect of irrigation levels

Results illustrated in Table 1 show highly significant effect of different irrigation levels on shoot/root by weight (Sh/R_W), length (Sh/R_l) and leaf area index (LAI) at both summer studied seasons but it has no significant effect on Sh/R_L in 2017 season. Irrigation levels by 1.2 and 0.9 m^3day^{-1} gave the highest value for each of Sh/R_W (7.548, 7.904) and Sh/R_L (7.655, 10.498) at 2016 and 2017 seasons. In concern to leaf area, results in Table 1 show highly significant effect of irrigation treatments on sunflower leaf area means at both seasons. Largest values of leaf area (185.94 and 89.72 dm^2/plant) obtained from I_3 treatment when compared to the other studied ones in both seasons. Also, I_3 (0.6m^3day^{-1}) gave the maximum values of LAI (37.187, 17.773).

It is important to determine growth analysis criteria as the biological and economic yield depends largely on both shoot/root ratios and leaf area amount, speed and duration. In this study, the negative impact of lower irrigation levels mitigated leaf area degradation of adequate water amount round root zone, so, enough and accumulated sufficient leaf area, was comparable to that at optimal irrigated level. However, **Rauf *et al.* (2009)** found that repressing effect of drought was observed on root weight and shoot length while root length and root-to-shoot ratio showed higher values under drought stress. Sunflower plants under inadequate irrigation level responded to reducing their heights to keep more water content, while at suitable irrigation level (I_1) proved to be essential for achieving desired up ground growth, while discontinuity of irrigation water to sunflower at early stage resulted in severe disadvantage for plant growth that caused poor vegetative growth **(Buriro *et al.*, 2015).** These findings are similar to those obtained by **Ali and Ullah (2012) and Ma *et al.* (2016).**

Genotypes variation

Results in Table 1 show highly significant variation among all the studied genotypes and two comparative cultivars at both seasons. Superiority was found for Giza-102 followed by G_3 and G4 in both

Table 1. Effect of different irrigation levels and sunflower genotypes on growth analysis after 45 days from sowing at 2016 and 2017 summer seasons

Irrigation level (m^3day^{-1})	Shoot /Root weight ratio		Shoot/Root length ratio		leaf area (dm^2 $plant^{-1}$)		Leaf area index (LAI)	
	2016	2017	2016	2017	2016	2017	2016	2017
I_1	7.548 a	7.904 a	102.200 b	84.294 b	102.200 b	84.294 b	2.0440 b	1.6859 b
I_2	8.205 a	7.791 ab	112.809 b	66.767 c	112.809 b	66.767 c	2.2562 b	1.3354 c
I_3	5.587 b	6.656 b	185.938 a	89.720 a	185.938 a	89.720 a	3.7187 a	1.7773 a
I_4	6.931 ab	6.659 b	172.430 b	88.602 b	172.430 b	88.602 b	3.4486ab	1.7020 ab
F-test at 0.05 level	**	*	**	**	**	**	**	**
				Genotype				
G_1	7.172bc	8.382 b	5.839c	8.793b	216.738 a	103.449 b	4.3348 a	2.0739 b
G_2	6.703bc	5.234c	6.273bc	9.472b	117.221 b	54.697 c	2.3446 b	1.0940 c
G_3	8.225ab	7.640bc	7.244ab	12.272a	90.562 b	43.447 c	1.8111 b	8.690 c
G_4	7.022bc	7.692bc	7.612a	8.249b	135.434 b	87.829 bc	2.7086 b	1.7566 bc
G_5	5.376c	7.686bc	6.344bc	11.156a	112.388 b	54.910 c	2.2478b	1.0983 c
Giza-102	9.184a	9.623a	8.060a	11.999a	125.014 b	66.730 bc	2.5003 b	1.3344 bc
Sakha-53	5.791c	5.511c	6.393bc	8.133b	206.052 a	158.360 a	4.1209 a	3.1673 a
F-test at 0.05 level	**	**	**	**	**	**	**	**

I_1=1.2, I_2=0.9, I_3=0.6, I_4=0.3 m^3day^{-1}, G_1=P.L120, G_2=P.L125, G_3=P.L240, G_4=P.L770, G_5=P.L990). Numbers had the same letters had no significant differences according to DMRT

Shoot/Root weight and length ratio. In concern to means of sunflower genotype leaf area, of G_1 and Sakha 53 gave the highest mean values (216.783 and 206.052 dm^2 $plant^{-1}$) at the 1st season, while Sakha 53 gave the highest one (158.360 dm^2 $plant^{-1}$) followed by G_1 (103.449 dm^2 $plant^{-1}$) at the 2nd season. These results may showed this superiority for Sakha 53 and G_1 as their closer relationship of parents. Also,Sakha 53 gave the maximum values of leaf area index (4.1209 and 3.1673), followed by G_1 (4.3348 and 2.0739). This may refer to the high ability of these genotypes and cultivars to accumulate carbohydrates by healthy root system even under water stress conditions. Root characteristics are important during breeding for drought tolerance (**Rauf, 2009**). A lot of studies indicated the deep relationship between higher root growth with better drought tolerance (**Rauf *et al.*, 2009**). Similar studied have been reported by **El Sarag (2007), Babaiy *et al.* (2009), Abd El-Motagally and Osman (2010), Freitas *et al.* (2012), Abaza (2010), Abd El-Satar *et al.* (2017) and Bagheri *et al.* (2018).**

Interaction effect between irrigation intervals and genotypes (I x G)

According to the results in Table 2, I_1 x Giza-102 (2016) and G_1 (2017) gave the highest values of Shoot/Root weight ratio (14.428 and 16.656), while the lowest ones were obtained from the interactions of I_4 x G_2 (2016) and I_1 x G_2 (2017) (3.113 and 2.813). For Shoot/Root length Ratio, I_4 x G_3 recorded the highest ratio (10.522 and 15.371)

Table 2. Interaction effect of different irrigation levels and some sunflower Genotypes (I x G) on growth analysis at 2016 and2017 summer seasons

Irrigation levels (m^3/day)	Genotypes	Shoot /Root weight ratio		Shoot\Root length ratio		Leaf area (dm^2 $plant^{-1}$)		Leaf area index (LAI)	
		2016	2017	2016	2017	2016	2017	2016	2017
I1	G_1	7.285 c-f	16.656 a	7.323 b-h	11.680 bcd	130.480cde	85.637 cd	2.6100 cde	1.7127 cd
	G_2	5.366 def	2.813 j	8.860 a-d	14.867 ab	52.707 e	33.153 d	1.0543 e	0.2633 d
	G_3	8.597 bcd	4.371 g-j	7.180 b-h	10.028 c-h	62.278 e	30.787 d	1.2453 e	0.4157d
	G_4	6.940 c-f	6.642 c-j	8.196 a-f	7.829 e-i	108.997cde	71.880 cd	2.1800 cde	1.0377 cd
	G_5	4.273 def	11.097 b	6.013 e-k	11.417 cde	143.197cde	60.733 cd	2.8640 cde	1.0147 cd
	Giza-102	14.428 a	5.180 e-j	9.778 ab	9.944 c-h	63.410 e	90.693 cd	1.2680 e	1.8140 cd
	Sakha-53	5.945 def	8.573 b-f	6.236 d-k	7.726 e-i	154.333cde	277.177 a	3.0863 cde	5.5433 a
I2	G_1	8.174 cde	6.987 c-h	5.810 f-k	7.921 e-i	134.507cde	129.810 bc	2.6900 cde	2.5960 bc
	G_2	12.277 ab	9.597 bcd	7.206 b-h	8.452 d-i	144.540cde	89.333 cd	2.8910 cde	1.7867 cd
	G_3	7.890 cde	7.545 b-h	4.951 h-k	11.317 cde	94.793cde	34.630 cd	1.8957 cde	0.6927 cd
	G_4	7.621 cde	8.956 b-e	9.462 abc	9.190 c-i	51.553 e	83.803 cd	1.0310 e	1.6760 cd
	G_5	6.219 def	7.894 b-g	3.882 k	10.745 c-g	111.470cde	54.733 cd	2.2293 cde	1.0950 cd
	Giza-102	7.517 cde	9.500 bcd	5.972 e-k	12.191 a-d	188.290bcd	20.873 d	3.7660 bcd	0.4173 d
	Sakha-53	7.736 cde	4.054 hij	7.064 c-i	10.769 c-g	64.510 e	54.187 cd	1.2903 e	1.0840 cd
I3	G_1	7.304 c-f	8.034 b-g	5.734 f-k	8.984 c-i	203.253 ab	96.857 cd	8.0650 a	0.1957 cd
	G_2	6.056 def	5.424 e-j	3.964 k	5.657 i	191.663 bc	77.643 cd	3.8333 bc	1.5530 cd
	G_3	5.621 def	8.769 b-f	6.325 d-k	12.373 abc	112.513 cde	64.490 cd	2.2503 cde	1.2900 cd
	G_4	5.767 def	7.573 b-h	8.576 a-e	8.741 c-i	121.560 cde	83.690 cd	2.4310 cde	1.6740 cd
	G_5	6.038 def	6.804 c-i	7.764 b-f	11.080 c-f	134.903 cde	77.963 cd	2.6980 cde	1.5593 cd
	Giza-102	4.141 ef	5.839 d-j	6.774 d-j	10.862 c-g	152.830 cde	98.387 bcd	3.0567 cde	1.9677 cd
	Sakha-53	4.182 ef	4.146 g-j	7.464 b-h	7.511 f-i	184.840bcd	101.010 bcd	3.6967 bcd	2.0203 cd
I4	G_1	5.925 def	5.851 d-j	4.489 ijk	6.587 hi	198.713 bc	101.493 bcd	3.9740 bc	2.0300 cd
	G_2	3.113 f	3.104 ij	5.064 g-k	8.914 c-i	79.973 de	38.657cd	1.5997 de	0.7730 cd
	G_3	10.792 abc	9.874 bc	10.522 a	15.371 a	92.663cde	53.880 cd	1.8530 cde	1.0777 cd
	G_4	7.759 cde	7.596 b-h	4.214 jk	7.238 ghi	259.627 b	131.943 bc	5.1923 b	2.6387 bc
	G_5	4.974 def	4.947 f-j	7.718 b-g	11.383 cde	59.983 e	36.210 d	1.2000 e	0.7243 cd
	Giza-102	10.649 abc	9.972 bc	9.715 ab	15.000 ab	95.527 cde	56.967 cd	1.9107 cde	1.1387 cd
	Sakha-53	5.302def	5.271 e-j	4.809 h-k	6.527 hi	220.527 a	201.067 ab	8.4103 a	4.0213 ab
F-test at 0.05 level		**	**	**	**	**	**	**	**

I_1=1.2, I_2=0.9, I_3=0.6, I_4=0.3 m^3day^{-1}, G_1=P.L120, G_2=P.L125, G_3=P.L240, G_4=P.L770, G_5=P.L990). Numbers had the same letters had no significant differences according to DMRT comparing to the other interactions at both seasons. The maximum values of sunflower leaf area (220.527, 277.177 dm^2 $plant^{-1}$) was found by I_4 and I_1 x Sakha 53 at 2016 and 2017 seasons. While, the smallest sunflower leaf area (59.983, 36.210 dm^2 $plant^{-1}$) was recorded for I_4 x G_5 at both seasons. However,the highest LAI (8.0650 and 8.4103) were obtained from $I_3 \times G_1$ and I_4×sakha 53 at 2016 season, while it was 5.543 from I_1×sakha 53 followed by (4.021) I_4×sakha 53 at 2017 season.

Yield and its Attributes

Effect of irrigation intervals

There are highly significant effect of the studied irrigation treatments on sunflower genotypes yield and its attributes in both seasons (Table 3). Irrigation treatments by 0.9 and $0.3m^3day^{-1}$gave the highest head diameter (20.38 and 24.21 cm) in 2016 and 2017 seasons. However, I_2 (0.9 m^3day^{-1}) gave superiorities of head weight (494.9 and 601.7 g), seed head weight (82.48 and 101.57 g) at both seasons and 100-seed weight (9.81 g) at 2016 season as compared with the other irrigation treatments. In 2017 season, I_3(0.6 m^3day^{-1}) gave the highest 100-seed weight (10.41 g) followed by I_4 (0.3 m^3day^{-1}) one, which gave mean of 9.78g. There were no significant differences between I_1 and I_2 treatments on seed yield (1.357 and 1.385 ton fed^{-1}) at 2016 and (1.459 and 1.704 ton fed^{-1}) at 2017 season. These results may refer to sunflower ability with adapted root system to absorb irrigation water under scarcity conditions. Similar findings were reported by **Saeed *et al.* (2015),** where, they concluded that increasing the amount of irrigation water significantly increased head diameter, leaves weight/plant, head weight/plant, seeds weight/ head, 100 seeds weight, seed yield, root weight, length and width.

Genotypes variation

According to the results shown in Table 3, Sakha 53 gave the highest value (21.58 cm) of head diameter followed by G_1 and G_4 (P. L120 and P. L770) which valued as 20.75 and 20.76 cm in 2016 season, while, G_1 and G_4 gave the biggest heads (24.75 and 24.63 cm) followed by Giza 102 and Sakha 53 (23.55 and 23.53 cm) in 2017 season. For head weight, Sakha 53 and G_4(P. L770) gave the highest mean values (488.6 and 647.8 g) in 2016 and 2017 seasons. However, the superiorities of seed head weight were reported to G_1 (P. L120) at both seasons but G_4(P. L770) and G_5 (P. L990) at 2016 and 2017 seasons, which valued 81.63, 93.19 g and 83.95 and 93.25 g, respectively. Similar trend was reported for seed yield per feddan, where G_4 gave the highest values (1.410, 1.584 t fed^{-1}) followed by G_1,G_3,G_5 and Sakha 53 in both seasons, followed by G_1,G_2,G_3,Giza 102 and Sakha 53 in the 1th season.. These superiorities may be due to their genetic constitution and its capability of withstanding climatic fluctuation and soil conditions which may also related to the increase in root length, leaf area, leaf area index and head diameter.

Interaction effect (I x G)

Results in Table 4 show significant effect of irrigation treatments and sunflower genotypes and cultivars interaction on all yield and its components characters at both seasons. Interaction of I_2 and/or I_3 x Sakha-53 gave the highest head diameter (23.00 cm) in 2016 season, while, I_1 x G_4 reported the highest mean (28.00 cm) in 2017 season. In the other hand, the lowest head diameter values were obtained from I_4 x G_5 in both seasons and I_1 x G_3 in 2017 season. However, the heaviest heads (611.33 and 893.00 g) were gained with interactions of I_2 x Sakha 53 and I_4 x G_3 at respective seasons but the lightest ones (245.33 and 227.00 g) were found with I_4 x Giza 102 and I_1 x G_3 at 2016 and 2017 seasons.

Table 3. Effect of different irrigation levels and sunflower genotypes on yield and its attributes at 2016 and 2017 summer seasons

Irrigation levels (m^3 day^{-1})	Head diameter (cm)		Head weight (g)		Seed head weight (g)		100-seed weight		Seed yield (ton fed^{-1}.)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
I_1	19.11 b	22.79 c	407.1 b	507.1 b	80.86 ab	86.86 b	8.86 c	8.57 c	1.357a	1.459a
I_2	20.38 a	23.50 b	494.9 a	601.7 a	82.48 a	101.57 a	9.81 a	9.29 b	1.385a	1.704a
I_3	20.19 ab	22.69 c	378.5 b	490.5 b	77.04ab	84.18 b	9.67 a-b	10.41 a	1.290b	1.313b
I_4	19.91 b	24.21 a	369.1 b	641.3 a	66.02 c	72.13 c	8.99 b-c	9.78 ab	1.110b	1.211b
F- test at 0.05 level	*	**	**	**	**	**	*	**	**	**
Genotypes										
G_1	20.75 b	24.75 a	401.2 ab	572.3 abc	81.63 a	93.19a	9.31 ab	8.91 b	1.370ab	1.465ab
G_2	19.08 d	22.63c	401.8 ab	505.3 c	67.33 b	74.94b	9.20 ab	9.46 b	1.131b	1.258b
G_3	20.00 bc	22.75 bc	417.3 ab	528.0 bc	79.00ab	89.75ab	9.50 ab	9.00 b	1.327ab	1.508ab
G_4	20.67 b	24.63 a	402.2 ab	647.8 a	83.95 a	88.35ab	10.00 a	10.71 a	1.410a	1.584a
G_5	19.50 cd	21.25 d	408.3 ab	526.8 bc	78.50ab	93.25a	8.83 b	9.75b	1.319ab	1.566ab
Giza-102	19.08 d	23.55 b	367.5 b	600.3 ab	69.67 b	74.60b	9.17 ab	9.53 b	1.170ab	1.253b
Sakha-53	21.58 a	23.53 b	488.6 a	540.9 bc	76.12 ab	89.21ab	9.33 ab	9.24 b	1.278ab	1.498ab
F-test at 0.05 level	**	**	*	**	**	**	**	**	**	**

I_1=1.2, I_2=0.9, I_3=0.6, I_4=0.3 $m^3 day^{-1}$, G_1=P.L120, G_2=P.L125, G_3=P.L240, G_4=P.L770, G_5=P.L990). Numbers had the same letters had no significant differences according to DMRT

Table 4. Interaction effect of different irrigation levels and some sunflower Genotypes (I x G) on yield and its attributes at 2016 and2017 summer seasons

Irrigation levels (m^3 day^{-1})	Genotypes	Head diameter (cm)		Head weight (g)		Seed head weight (g)		100-seed weight (g)		Seed yield (ton fed^{-1}.)	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
	G_1	19.67 d-h	23.00 f-i	266.7 fgh	314.00jk	76.00a-e	79.00bcd	7.00 c	7.00 c	1.279a-e	1.327jk
	G_2	19.00 f-i	21.50ijk	504.0 a-d	583.00d-g	88.00a-d	91.00bcd	8.67 abc	9.00 abc	1.344ab	1.528c-f
	G_3	18.00 hi	19.50 l	257.3 gh	227.00k	74.67a-e	76.67 b-e	9.33 abc	8.00 bc	1.253a-e	1.288h-k
I_1	G_4	21.33 a-d	28.00 a	490.7 a-e	778.00abc	95.33ab	96.33abc	10.66 a	11.00 a	1.601a	1.618a
	G_5	20.67 b-f	21.50 ijk	486.7 a-e	435.00ghij	77.33a-e	80.33 b-e	8.67 abc	9.000abc	1.298a-e	1.349e-i
	Giza-102	18.67 ghi	24.00 efg	383.3 c-h	720.00bcd	73.33a-e	76.33 b-e	8.67 abc	8.000bc	1.232a-e	1.282c-h
	Sakha-53	22.00 abc	22.00 h-k	460.7 a-g	493.00e-i	81.33a-e	85.33cde	8.67 abc	8.00 bc	1.366a-d	1.433d-h
	G_1	20.33 c-g	27.00 ab	604.0 ab	703.10bcd	89.33abc	94.33 a-d	10.67a	9.00 abc	1.501a-d	1.583 bc
	G_2	18.00 hi	21.50 ijk	395.3 b-h	310.00jk	59.33cde	66.33cde	9.33 abc	9.00 abc	0.996c-f	1.114 e-j
	G_3	20.67 b-f	23.00 f-i	543.3 a-d	567.00d-h	88.67abc	90.67bcd	9.33 abc	8.00 bc	1.489a-d	1.523b-f
I_2	G_4	19.00 f-i	20.50 kl	264.00fgh	447.00f-j	75.33a-e	77.33cde	9.333abc	11.000 a	1.265 a-f	0.965 ijk
	G_5	20.33 c-g	21.50 ijk	476.67a-f	635.00cde	83.33a-e	88.33b-e	9.33 abc	11.00 a	1.399a-e	1.484bc
	Giza-102	21.33 a-d	25.00cde	570.00abc	860.00ab	90.67abc	93.67abc	10.00 ab	8.00 bc	1.523a-d	1.573e-h
	Sakha-53	23.00 a	26.00 bcd	611.33a	690.00cd	90.67abc	95.67abc	10.67 a	9.00 abc	1.523a-d	1.607ab
	G_1	21.67 abc	24.50 def	454.00a-h	609.00def	94.00abc	95.00abc	9.33 abc	10.00 ab	1.579a-d	1.596bcd
	G_2	19.00 f-i	21.00 jkl	290.00efgh	405.00hij	52.83de	56.83cde	9.73 abc	9.85 ab	0.851f	0.554k
	G_3	19.00 f-i	21.00 jkl	351.33d-h	425.00g-j	71.33a-e	74.33b-e	9.33 abc	11.00 a	1.198b-f	1.248c-g
I3	G_4	21.00 b-e	24.00 efg	422.00a-h	582.00d-g	100.00a	109.00a	10.00 ab	11.00 a	1.679abc	1.831b-e
	G_5	19.33 e-i	22.50 g-j	389.33c-h	617.00cde	89.33abc	90.33abc	10.00 ab	10.00 ab	1.500a-e	1.517c-f
	Giza-102	18.33 hi	22.20 g-k	271.33fgh	395.10ij	64.00b-e	66.00cde	9.33 abc	11.10 a	1.075def	1.108jk
	Sakha-53	23.00 a	23.60 e-h	471.67a-f	400.55hij	67.80a-e	68.80b-e	10.00 ab	9.95 ab	1.139c-f	1.155jk
	G_1	21.33 a-d	24.50 def	280.000efgh	663.00cd	67.20a-e	71.20b-e	9.23 abc	9.65 ab	1.129b-f	1.196ijk
	G_2	20.33 c-g	26.50 abc	418.00a-h	723.00bcd	69.13a-e	72.13b-e	9.07 abc	10.00 ab	1.161a-f	1.212ijk
	G_3	22.33 ab	27.50 ab	517.33abcd	893.00a	81.33a-e	86.33b-e	10.00 ab	9.00 abc	1.366a-e	1.449c-g
I4	G_4	21.33 a-d	26.00 bcd	432.00a-h	784.00abc	65.13a-e	67.13b-e	9.37 abc	9.85 ab	1.094b-f	1.128h-k
	G_5	17.67 i	19.50 l	280.67e-h	420.00ghij	64.00b-e	67.00b-e	8.33 bc	9.00 abc	1.075b-f	1.126g-k
	Giza-102	18.00 hi	23.00 f-i	245.33h	426.00ghij	50.67e	53.67e	8.67 abc	11.00 a	0.887ef	0.901jk
	Sakha-53	18.33 hi	22.50 g-j	410.67a-h	580.00d-g	64.67a-e	65.67b-e	8.00 bc	10.00 ab	1.086b-f	1.103f-j
F-test at 0.05 level		**	**	**	**	**	**	**	*	**	**

I_1=1.2, I_2=0.9, I_3=0.6, I_4=0.3 $m^3 day^{-1}$, G_1=P.L120, G_2=P.L125, G_3=P.L240, G_4=P.L770, G_5=P.L990). Numbers had the same letters had no significant differences according to DMRT

According to seed head weight, maximum values (100.00 and 109.00 g) were obtained when I_3 interacted with G_4 but the minimum values (50.67 and 53.67 g) were gained with I_4 x Giza 102 at both studied seasons. Interactions of I_1 x G_4, I_2 x $G_1$and I_2 x Sakha 53 gave the highest 100-seed weight valued 10.66 and 10.67 and 10.67 g in 2016, while, 100-seed weight of 11.00 g was the maximum value and was recorded for multiple interactions (I_1 x G_4, I_2 x G_4, I_2 x G_5, I_3 x G_4, I_3 x G_5, I_3 x Giza 102, I_4 x Giza 102) in 2017 seasons. However, the lowest values of 100-seed weight (7.00 g) were obtained from I_1 x G_1 interaction at both seasons. In concern to seed yield, I_1 x G_4 interaction gave the highest means (1.601 and 1.618 ton fed^{-1}), while the lowest values (0.851 and 0.554 ton fed.$^{-1}$) were gained from I_3 x G_2 in 2016 and 2017 seasons.

Conclusion

This study is a great opportunity, for increasing sunflower seed production in Egypt and lessen the gap between oil production and consumption. G_4 (P. L770) surpassed all the other studied genotypes and gave the highest seed yield per feddan in all studied.

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الملخص العربي

تحليل النمو والمحصول تحت تأثير مستويات الري لبعض سلالات وأصناف دوار الشمس تحت ظروف الأراضي الرملية

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المياه عامل محدد لنمو النبات و تطوره، حيث ان ميعاد وكمية استخدامها يلعب دورا هاما في زيادة المحصول مع توفير المياه خاصة في التربة الرملية ذات القدرة المنخفضة على الاحتفاظ بالمياه . ومن شأن المستوى الامثل للري ان يساعد في تحسين العائد الاقتصادي فضلا عن كفاءة استخدام المياه . يعد دوار الشمس (*Helianthus annuus* L.) من النباتات التي تأثرت بإمدادات المياه وفقاً لنموها الخضري الكبير ومنطقة النتح . وهو زيت أساسي للطعام في كثير من البلدان في جميع انحاء العالم والذى يحتل المرتبة الرابعة بعد الفول السوداني وفول الصويا وزيت الكانولا. لذلك تهدف هذه الدراسة الى اختبار تأثير أربعة مستويات للري (I_1=1.2, I_2=0.9, I_3=0.6. I_4=0.3 m^3/day/plot area) وسبعة سلالات منها خمسة سلالات وراثية (G_1=P.L 120, G_2=P.L 125, G_3=P.L 240, G_4=P.L 770, G_5=P.L 990) واثنان من اصناف عباد الشمس (Sakha-53, Giza-102) تحت ظروف شمال سيناء خلال موسمي ٢٠١٦ و٢٠١٧.اشتملت الدراسة على ٢٨ معاملة (٤×٧) . اظهرت النتائج ان اعلى قيمة لوزن بذور القرص هى ١٠٠ و ١٠٩ جرام وتم الحصول عليها من المعاملات G_4× I_3 فى كلا الموسمين . بينما وزن ال١٠٠ بذرة كان ١٠,٦٦ و ١٠,٦٧ جرام وذلك من المعاملات G_4× I_1 و53 sakha× I_2 فى ٢٠١٦ ،فى حين انة فى الموسم الثانى كانت اعلى قيمة هى ١١,٠٠ جرام والتى نتجت من المعاملات I_1×G_4 و I_2×G_5 وGiza 102 I_3 ×G_3,G_4 and Giza 102 و I_4×Giza 102 .

الكلمات الإسترشادية: التراكيب الوراثية لدوار الشمس، الاصناف،مستويات الرى، المحصول، مساهمات المحصول.

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