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Effect of Irrigation Escaping at Different Times on Growth and some Water Relations of Sunflower at North Nile Delta

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TWO field experiments were conducted at El-Karada water management station, Kafr El-Sheikh Governorate, Egypt, during two successive seasons of 2008 and 2009. The present work was carried out to evaluate the effect of irrigation escaping at different times through the growing season on plant growth attribute of sunflower grown at North Nile Delta, photosynthetic pigments, amount of water saving and irrigation water productivity. Randomized complete block design with three replications was used. The irrigation treatments included five treatments conventional irrigation along the growing season every 15 days (T_1), escaping irrigation at the age of 30 days from sowing = 3^{rd} irrigation (T_2), escaping irrigation at the age of 45 days from sowing = 4^{th} irrigation (T_3), escaping irrigation at the age of 60 days from sowing = 5^{th} irrigation (T_4) and escaping irrigation at the age of 75 days from sowing = 6^{th} irrigation (T_5). The results showed that T_4 had the highest values of crop water efficiency (0.77 kg m^{-3}) and irrigation water productivity (0.62 kg m^{-3}) as an overall average of the two seasons. From the view point of irrigation water saving, T_4 and T_5 recorded the highest values of irrigation water saving, with nearly the same amount, 511 and 519 m^3/fed as an average of the two seasons, respectively. Data also revealed that irrigation escaping dates had a significant effect on leaf area, crop growth rate, net assimilation rate and relative growth rate in both growing seasons. The highest values of the abovementioned characters were obtained under T_3 followed by T_4 in both growing seasons at the second period (75-90) days after sowing. Also, chlorophyll a and b and carotenoids concatenation were significantly affected by the irrigation escaping dates and the highest values were recorded under T_4 and T_5 at the age of 60 days after sowing in both seasons. It could be concluded that the 5^{th} irrigation (T_4) is the best water management for sunflower crop since it saved water by 18.2% relative to control treatment and had the highest values of crop water use efficiency and irrigation water productivity.

Keywords: Water relations, Sunflower, Escaping irrigation, Growth attributes, Chlorophyll a and b , Carotenoids.

In Egypt, due to the severe shortage in edible oil and due to the rapid population increase, sunflower received a great attention. At present, Egypt imports abut 80-85% of its annual requirements of edible vegetable oils. A possible remedy to the present gap between the domestic production and demand for edible oil could be achieved by conduction numerous investigation about the effect of fertilization, sowing dates and irrigation treatments on maximizing the productivity of sunflower under local climatic conditions. Because of the water limitation faced Egypt, we should do our best towards effective rationalization of irrigation at farm level. Gad El-Rab *et al*. (1993) indicated that imposing sunflower plants to drought conditions decreased plant height and heed diameter as well as water consumptive use. 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). Even limited irrigation water, applied at different growth stages of sunflower, can significantly increase seed yields, especially during three growth periods: heading, flowering, and milking stages; at three growth stages (heading, beginning of flowering and end of flowering) and at 50% ray flower stage (Goksoy *et al.,* 2004). Soleimanzadeh *et al.* (2010) reported that plant height, diameter of head, number of seeds per head, 1000 seeds weight, biological yield, seed yield, harvest index and oil yield were declined under drought stress. It has been reported that harvest index decreased with increasing water stress (Soriano *et al.,* 2004).

The main objective of this study was to evaluate the effect of escaping irrigation at different ages of sunflower from sowing on growth attributes, photosynthesis pigments and some water relations such as crop water use efficiency and irrigation water productivity at North Nile Delta area.

Material and Methods

The present investigation was carried out at El-Karada Water Management Station Farm, Kafr El-Sheikh Governorate during two successive summer seasons 2008 and 2009. Kafr El-Sheikh is located at 31^{o} 07^{-}N latitude and 30^{o} 52^{-}E longitudes and has elevation about 6 m above sea level. The studied site is clay in texture. The main analytical values were clay 51.7%, silt 26.1%, sand 21.2%, EC 2.59 dS m^{-1} in soil paste extract, pH 8.05, organic matter 13.8 g kg^{-1}, field capacity 44.7% and wilting percent 24.2%. Randomized complete block design with three replications was used in both seasons (Gomez and Gomez, 1984).

The irrigation treatments included five treatments as follows:-
T_1: Conventional irrigation along the growing season every 15 days (control).
T_2: Escaping irrigation at the age of 30 days after sowing (DAS), (3^{rd} irrigation).
T_3: Escaping irrigation at the age of 45 DAS, (4^{th} irrigation).
T_4: Escaping irrigation at the age of 60 DAS, (5^{th} irrigation).
T_5: Escaping irrigation at the age of 75 DAS, (6^{th} irrigation).

Each plot area was 42 m^2 including 10 ridges, 7 m long and 0.60 cm apart. Plots were isolated by ditches of 1.5 m in width to avoid lateral movement of water. Seed of sunflower cultivar Sakha 53 was sown on March 15th (2008) and 19th (2009) at hills 20 cm apart on one side of the ridges and harvested on July 7 and 17 in both seasons, respectively. In both seasons, phosphorous fertilizer in the form of calcium super phosphate (15.5 % P_2O_5) was applied at the rate of 31 kg P_2O_5/fed during land preparation. Nitrogen was added in the form of urea (46% N) at the rate of 40 kg N/fed in two equal doses before the first and second irrigations, respectively. Potassium was added in the form of potassium sulphate (48% K_2O) at the rate of 24 kg K_2O /fed. Thinning practices were conducted after 21 days from planting to sear one plant per hill. Other practices for growing sunflower were conducted as recommended by Ministry of Agriculture and Land Reclamation (2006). The growth attributes, viz-leaf area (LA) per plant in square decimeters (dm^2) of three samples at 60, 75 and 90 DAS were measured by leaf area index instrument (Rawson and Turner, 1983). Relative growth rate (RGR), crop growth rate (CGR) and net assimilation rate (NAR) were measured according to the formula mentioned by Hunt (1990). These formulas could be summarized as follows:-

$CGR = (w_2 - w_1) / (t_2 - t_1)$, g/$m^2$/week.

$NAR = (w_2 - w_1) (\log A_2 - \log A_1) / (A_2 - A_1) (t_2 - t_1)$, g/$m^2$/week.

$RGR = (\log w_2 - \log w_1) / (t_2 - t_1)$, g /g /week.

Where: w_1, A_1 and w_2, A_2 respectively refer to dry weight and leaf area at time t_1 and t_2 in week.

The amount of chlorophyll pigments (chlorophyll a and b) was determined using spectrophotometer and calculated according to Sadasivam and Manickam (2005). Carotenoids were determined according to Wang *et al*. (2005) at 60, 75 and 90 DAS.

Ten guarded plants were randomly taken from the fourth inner ridges to determine plant height and head diameter. Irrigation water was applied through a weir and the water amount was calculated by using the following equation:

$$Q = 1.84\ LH^{1.5}$$

Where: Q = Rate of discharge, m^3 / sec.
L = length edge of weir, cm .
H = Height of water above edge of weir, cm (USBR 1997).

Water consumptive use (WCU) was determined by the soil moisture depletion method. Soil samples were taken before each irrigation using auger and after 48hr from each irrigation at (0-60 cm) depth. Moisture content in the soil samples was determined gravimetrically and calculated on weight basis to calculate the WCU using the following equation (Israelsen and Hansen, 1980).

$$WCU = \frac{\theta_2 - \theta_1}{100} \times \rho_a \times D \times 4200$$

Where:

WCU = Amount of water consumptive use (m^3/fed).
θ_2 = Soil moisture content % after irrigation.
θ_1 = Soil moisture content % before the next irrigation.
ρ_a = Bulk density (Mg/m^3).
D = Depth of soil layer (m).

Crop water use efficiency (CWUE), kg/m^3 was calculated as the ratio of yield on WCU according to Doorenbos and Pruitt (1977) as follows:

$$CWUE = \frac{\text{Yield (kg/ feddan)}}{\text{water consumptive use } (m^3/\text{feddan})}$$

Irrigation Water Productivity (IWP), kg/m^3 was calculated according to Ali *et al.* (2007) as follow:

$$I_{WP} = \frac{\text{Yield (kg/ feddan)}}{\text{water applied } (m^3/\text{feddan})}$$

The obtained data were subjected to analysis of variance according to Gomez and Gomez (1984). Treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955). All statistical analysis was performed using analysis of variance technique by means of "MSTATC" computer software package.

Results and Discussion

Effect of irrigation water escaping on growth and yield of sunflower

Data in Table 1 presented the effect of irrigation water escaping on plant height and head diameter. Irrigation treatments had significant effect on plant height and head diameter in the 1^{st} season but these traits were significantly affected by irrigation escaping in 2^{nd} season only. The highest values of plant height (161.8 and 164.8 cm) were recorded under T_2, while that of the head diameter (17.6 and 15.7 cm) were recorded under T_1 in the 1^{st} and 2^{nd} season, respectively. The lowest values were obtained under T_5 for the two traits in the same two seasons. The highest values of seed yield (3.41 Mg ha^{-1}) were recorded under T_4 in both seasons. These results indicated that escaping irrigation during the late vegetative growth (T_5) results in reduced plant height but may increase root depth. Adequate water during the late vegetative period is required for proper bud development. The flowering period is the most sensitive to water deficit which causes considerable yield decrease since fewer flower come to full development (Beyazgul *et al*., 2000 and Ali & Shui, 2009).

TABLE 1. Effect of irrigation treatments on plant height, head diameter and seed yield of sunflower crop.

Variable	F-test	Treatments				
		T_1	T_2	T_3	T_4	T_5
Season 2008						
Plant height, cm	ns	153.6 a	161.8 a	145.8 a	143.4 a	141.2 a
Head diameter, cm	ns	17.6 a	16.9 a	17.6 a	17.8 a	17.2 a
Seed yield, Mg ha^{-1}	*	3.16 a	2.72 b	2.97 ab	3.41 a	2.95 ab
Season 2009						
Plant height, cm	*	164.3 a	164.8 a	154.3 ab	151.1 ab	136.8 b
Head diameter, cm	**	15.7 a	15.5 a	13.8 ab	13.6 b	14.9 ab
Seed yield, Mg ha^{-1}	*	3.16 a	2.69 b	2.95 b	3.41 a	3.18 a

*, ** and ns indicate $p< 0.05$, $p< 0.01$ and not significant, respectively. Means of each factor designed by the same letter are not significantly different at 5 % level using Duncan's MRT.

Data presented in Table 2 show a significant effect due to irrigation treatments on leaf area (dm^2) of sunflower in both seasons. Leaf area of sunflower increased by advancing age up to 75 DAS, and then slightly declined at 90 DAS in both seasons. This is mainly due to the production of new leaves, as well as, leaves expansion the growth of sunflower plant. The highest values of leaf area was obtained under T_3 (escaping irrigation at the age of 45 DAS) followed by T_5 in the first season, while it was under T_3 followed by T_2 in the second season. The results in Table 2 also, indicated that CGR and NAR values were higher in the second period (75 – 90 DAS) than the first one (60 – 75 DAS) in both growing seasons under all irrigation treatments. Also, data showed that both of CGR and NAR values of sunflower plants were significantly affected by irrigation treatments in both seasons. The highest values of CGR and NAR were obtained under T_4 followed by T_3 in the first season, while it was under T_3 followed by T_5 in the second one. On the other hand, RGR values were also significantly affected by irrigation treatments in both seasons. Similar results were obtained by Rawson and Turner (1983) and El-Kady (1987).

Data in Table 3 showed the effect of escaping irrigation on chlorophyll a and b and carotenoids in sunflower leaves at three growth stages (60, 75 and 90 DAS). It is clear from data that values of chlorophyll a and b and carotenoids at different growth stages were significantly affected by the irrigation treatments in the first season, while they were insignificantly affected in the second season. Also, data showed that values of chlorophyll a and b and carotenoids concentration were decreased as advancing age of plant in both growing seasons. The highest values of leaf chlorophyll a and b and carotenoids concentration were obtained at the age of plant 60 DAS under T_5 (escaping irrigation at 75 DAS) followed by T_4 (escaping irrigation at 60 DAS) . Whereas, values of chlorophyll a were 2.835 and 4.236 mg/dm^2 LA, chlorophyll b were 0.975 and 1.356 mg/dm^2 LA and carotenoids were 0.937 and 0.816 mg/dm^2 LA in the 1^{st} and 2^{nd} seasons, respectively. On the other hand, values of chlorophyll a and b and carotenoids content under T_4 and T_5 were higher than those under T_1 (irrigation along the growing season every 15 days, control) in the first season, except in the second season, values of chlorophyll a and b content at the age of 75 DAS were higher under T_1 compared to T_4 and T_5. These findings were agreement with those obtained by El-Kady (1987) and Gaafar & El-Wakil (1987).

TABLE 2. Effect of with holding irrigation on some growth attributes and leaf area of sunflower in both growing seasons .

Treatments	[1] RGR (g/g/week)		[2] CGR (g/m^2/week)		[3] NAR (g/m^2/week)		[4] LA (dm^2/plant)		
	Periods		Periods		Periods		DAS		
	60 - 75	75 - 90	60 - 75	75 - 90	60 - 75	75 - 90	60	75	90
Season 2008									
T1	0.32	0.27	124.4	235.8	29.5	56.1	48.6	55.0	47.3
T2	0.20	0.16	142.5	221.6	41.2	57.9	47.5	42.8	35.3
T3	0.20	0.17	110.2	253.2	18.4	66.1	53.3	54.1	39.0
T4	0.26	0.23	79.9	261.2	21.0	81.2	44.2	44.6	33.6
T5	0.30	0.25	109.6	190.8	16.8	81.9	50.7	47.5	42.1
F-test	ns	*	ns	*	*	ns	*	*	*
Season 2009									
T1	0.48	0.38	58.6	100.4	42.0	110.0	44.9	54.2	42.6
T2	0.37	0.20	108.1	180.2	47.2	85.3	57.1	65.6	62.4
T3	0.19	0.38	150.1	212.7	123.6	175.4	66.2	70.2	65.8
T4	0.52	0.16	108.6	144.1	37.8	150.3	48.3	50.4	44.0
T5	0.61	0.19	100.2	131.7	85.5	160.6	47.8	51.6	46.5
F-test	*	*	*	*	*	ns	*	*	*

*, ** and ns indicate p< 0.05, p< 0.01 and not significant, respectively. [1] RGR= relative growth rate, [2]CGR= crop growth rate, [3] NAR= net assimilation rate and [4] LA= leaf area.

TABLE 3. Effect of escaping irrigation on chlorophyll-a mg/dm^2 LA (Chl a), chlorophyll-b mg/dm^2 LA (Chl b) and carotenoids mg/dm^2 LA (Car) of sunflower leaves at the two growing seasons (2008 and 2009).

Treat.	DAS	Season 2008			Season 2009		
		Chl a	Chl b	Car	Chl a	Chl b	Car
T1	60	0.796	0.511	0.251	3.587	1.309	0.823
T2		1.216	0.559	0.414	3.148	1.535	0.663
T3		1.424	0.674	0.472	4.086	1.435	0.717
T4		2.684	0.923	0.882	3.975	1.289	0.933
T5		2.835	0.975	0.937	4.236	1.356	0.816
F-test		**	**	**	ns	ns	ns
T1	75	0.950	0.766	0.543	3.892	0.333	1.241
T2		1.947	0.985	0.674	2.905	0.539	0.851
T3		1.860	0.837	0.714	2.565	0.881	0.583
T4		2.399	0.903	0.881	3.026	1.008	0.781
T5		2.494	0.921	0.739	2.780	1.190	0.595
F-test		**	ns	**	ns	ns	ns
T1	90	1.715	0.972	0.707	2.390	3.135	0.141
T2		2.448	1.233	1.210	3.041	2.474	0.137
T3		2.268	0.882	0.974	2.061	2.458	0.165
T4		2.047	0.790	0.890	2.536	3.005	0.159
T5		1.882	0.795	0.870	3.721	2.792	0.381
F-test		ns	*	**	ns	ns	ns

*, ** and ns indicate p< 0.05, p< 0.01 and not significant, respectively.

Effect of irrigation water escaping on some crop water relations

The effect of irrigation water escaping on water applied (WA), water saving, water consumptive use (WCU), crop water use efficiency (CWUE) and irrigation water productivity (IWP) are presented in Table 4. The treatment of T_1 recorded the highest values of the water applied amounts (2823 and 2795 m^3 / fed), as well as the highest values of water consumptive use (2232 and 2264 m^3 / fed) in the two growing seasons 2008 and 2009, respectively. While T_4 and T_5 recorded the lowest values of the amount of water applied and the water consumptive use. This may be due to withholding the fifth irrigation for T_4 and the sixth irrigation for T_5, where plants are in physiological maturity that needs to the water increases with increasing plant age. Escaping the 6^{th} irrigation under T_5 induced the highest values of water saving and found to be (19.2 and 17.8%) in 1^{st} & 2^{nd} seasons, respectively. While, the lowest water saving percentage 13.3 and 12.9% were recorded under T_2, respectively, for the same seasons. The water consumptive use takes the same trend of water applied.

Data also, showed that the highest values of crop water use efficiency 0.75 & 0.793 kg/m^3 water and the highest values of irrigation water productivity 0.618 and 0.617 kg/m^3 in the 1^{st} & 2^{nd} seasons, respectively were obtained under T_4. While the lowest values of CWUE (0.552 and 0.588 kg/m^3) and IWP (0.463 and 0.465 kg/m^3) were obtained under T_2 in the two growing seasons, respectively. This could be attributed to the higher seed yield and lower amount of WA and WCU under T_4 than that under T_2. Flenet *et al*. (1996) found that water use efficiency was greater in stressed treatments than that in the well irrigated control, while Stone *et al*. (1996) and Goksoy *et al*. (2004) found that WUE did not significantly change when irrigation amount increased.

Conculusions

In north Nile Delta at Kafr El-Sheikh Governorate area, escaping irrigation at different times affected the studied plant growth attributes of sunflower differently. This effect was more pronounced in the 2^{nd} season than that in 1^{st} one, since most of the studied growth attributes were significantly affected by the irrigation escaping in particularly at 45 or 60 DAS.

From the view point of water, irrigation escaping for sunflower crop at the age of 60 DAS (the 5^{th} irrigation) is the best treatment since it saved water by about 18.2% over the two seasons, and had the highest values of CWUE (0.77 kg/m^3) and WP (0.62 kg/m^3) relative to the control treatment which irrigated every 15 days without irrigation escaping.

TABLE 4. Effect of irrigation escaping on water applied (WA), water saving, water consumptive use (WCU), crop water use efficiency (CWUE) and irrigation water productivity (IWP).

Characters		Treatments				
		T1	**T2**	**T3**	**T4**	**T5**
Season 2008						
WA (m^3/fed)	1^{st} irrigation	690	690	690	690	690
	2^{nd} irrigation	404	404	404	404	404
	3^{rd} irrigation	366	----	348	346	340
	4^{th} irrigation	465	461	----	438	432
	5^{th} irrigation	460	458	447	----	416
	6^{th} irrigation	439	434	415	418	----
	Total	**2824**	**2447**	**2304**	**2296**	**2282**
Water saving, (m^3/fed)		---	377	520	528	542
"	%	---	13.3	18.4	18.7	19.2
WCU(m^3/fed)		2232.2	2050.4	1956.4	1893.4	1879.4
CWUE(Kg/m^3)		0.590	0.552	0.633	0.750	0.653
IWP(Kg/m^3)		0.466	0.463	0.537	0.618	0.538
Seasons 2009						
WA (m^3/fed)	1^{st} irrigation	680	680	680	680	680
	2^{nd} irrigation	400	400	400	400	400
	3^{rd} irrigation	370	---	350	357	360
	4^{th} irrigation	460	465	---	439	425
	5^{th} irrigation	455	456	450	---	435
	6^{th} irrigation	430	435	440	425	---
	Total	**2795**	**2435**	**2320**	**2301**	**2299**
Water saving, (m^3/fed)		---	360	475	494	496
"	%	---	12.9	17.0	17.7	17.8
WCU(m^3/fed)		2264	1925	1799	1791	1778
CWUE(Kg/m^3)		0.582	0.583	0.683	0.793	0.746
IWP(Kg/m^3)		0.471	0.460	0.530	0.612	0.577

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أثر الحرمان من الري فى مراحل نمو مختلفة على النمو وبعض العلاقات المائية لنبات عباد الشمس في شمال دلتا النيل

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أجريت دراسه حقليه خلال موسم الصيف لعامي 2008 ، 2009 في محطة بحوث المقننات المائيه بمحافظة كفرالشيخ وكان الهدف منها دراسة أثر الحرمان من الري عند مواعيد مختلفه من الزراعه علي صفات النمو ، تركيز الكلورفيل أ ، ب والكاروتين ,وبعض العلاقات المائية لنبات عباد الشمس. وقد استخدم تصميم القطاعات العشوائية الكاملة فى ثلاث مكررات. شملت معاملات الري خمس معاملات: T_1 (الري طول موسم النمو كل 15 يوما)، T_2 (الحرمان من الري في عمر 30 يوم من الزراعة = الرية الثالثة)، T_3 (الحرمان من الري في عمر45 يوما من الزراعة = الرية الرابعة)، T_4 (الحرمان من الري في عمر 60 يوما من الزراعة = الرية الخامسة) وT_5 (الحرمان من الري في عمر 75 يوما من الزراعة = الرية السادسة). ولقد بينت الدراسه أن الحرمان من الري عند 60 ، 75 يوم من الزراعه (T_4 & T_5) أدت إلي توفير مياه الري في كلا الموسمين ، وكذلك تم الحصول على أعلى القيم لتوفير المياه (19,18 ، 75, 17%) تحت المعاملة الخامسة فى الموسم الاول والثانى على الترتيب. أيضاً أوضحت الدراسه أن أعلي قيم لمعدل نمو المحصول ، معدل التمثيل ، معدل النمو النسبى ،مساحة الورقة قد تحصل عليها في الفترة الثانية (75 – 90 يوم من الزراعة) في كلا الموسمين تحت معاملين T_4 & T_3 (الحرمان من الري عند 45 ، 60 يوم من الزراعة في كلا الموسمين على التوالى) . تحصل علي أعلي قيم لـ كلورفيل أ ، ب والكاروتين عند عمر 60 يوم من الزراعه تحت معاملتى T_4 ، T_5 في كلا الموسمين ثم ينخفض تركيزاتهم بتقدم العمر للنبات .

اتضح أن المعاملة الرابعة كانت أفضل المعاملات على صفات النمو وكفاءة استخدام المحصول للمياه ، كفاءة استخدام المياه على مستوى الحقل ، والتى يمكن أن نوصي بها فى ادارة مياه الرى لعباد الشمس فى شمال الدلتا تحت ظروف الدراسة .