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Response of Sunflower Yield and Water Relations to Sowing Dates and Irrigation Scheduling Under Middle Egypt Condition

Abdou, S. M. M. *, K.M. Abd El- Latif, Farrag, R. M. F. and Yousef, K. M. R.

Soils, Water and Environment Research Institute (SWERI), Agriculture Research Centre, ARC, Giza, Egypt

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ABSTRACT

Two field experiments were conducted during the 2009 planting seasons 2010 at the Tameia Agricultural Research Station, Fayoum, Egypt to study the combination effects of three sowing dates (D_1: 1st of June, D_2: 15th of June and D_3: 1st of July) and three irrigation scheduling treatments technique on yield, yield components and water relations such as seasonal crop water consumptive use (ET_C) and crop coefficient (K_c) of sunflower (Sakha 53 cv.). This was in accordance to the cumulative pan evaporation (C.P.E.), (I_1 0.8; I_2 1.0 and $I_3$1.2). A split- plot design with four replications was used. The results indicated that the sowing dates and irrigation scheduling treatments significantly affected seed yield and yield components in two seasons. The highest averages of plant height, head diameter, head weight, seed weight/head and 100 seed weight in two seasons were obtained from June 1st sowing and irrigation at 1.2 C.P.E. treatment. The highest seed yield 1050.1 and 1130.4 kg seeds/feddan however, July 1st sowing and irrigation at 0.8 C.P.E. gave the lowest values in the two seasons. The third sowing date (D_3) and irrigation at 0.8 C.P.E. gave the lowest seed yield/fed 560.7 and 596.2 kg seeds/feddan in two seasons, respectively were detected from (D_1I_3) in the two successive seasons. ET_C averaged 47.76 and 49.86 cm in two seasons, respectively. The highest ET_C values, 53.19 and 52.73 cm were recorded from (D_1I_3) in two seasons, respectively, whereas the lowest values, 42.18 and 44.19 cm in the two successive seasons were resulted from (D_3I_1). The daily ET_C rates were low during June, and increased during July to reach its peak during August then declined during September in both seasons. The K_C values, for high grain yield were 0.46, 0.65, 0.91, and 0.64 for June, July, August and September, respectively (as average in two seasons). The highest water use efficiency, i.e. 0.470 and 0.486 kg seeds/m^3 water consumed were obtained from (D_1I_3) treatment in two seasons, respectively.

Key words: sunflower yield, yield components, sowing dates, scheduling irrigation and water relations.

INTRODUCTION

Sunflower (*helianthus annuus L.)* is one of the most important oil crops around all the world countries. In Egypt great emphasis must be given towards this crop to decrease the gab in oil production. Sowing dates is one of the very important factors promoted the crop growth and yield. Also, irrigation water quantity and intervals play a great role in sunflower growth and yield production. Therefore, determining the optimum sowing date and irrigation water scheduling became very necessary for high seed yield under the Egyptian conditions.

Numerous studies have shown that yield and yield components of sunflower are reduced when normal sowing dates are delayed in both temperature [1] and subtropical [2] environments. The observed lower yields associated with late planting have been variously hypothesized as due to warmer temperatures during the growth period, which promotes excessive early stem growth and reduce time to flowering and to cooler temperatures and reduced incident radiation photosynthesis, which affects the dynamics of grain filling [2] 1998 and [3]. [4] reported that increasing season duration of maize from 90 to100 or 110 days increased seasonal consumptive use (ET_C). Delaying sowing sunflower dates led to reduce seasonal consumptive use and water use efficiency [5-7]

Regarding the effect of irrigation, [8-12] reported that irrigation sunflower at 25% available soil moisture (ASM) significantly decreased seed yield and its components.

[13 and 14] revealed that the crop water use vary from 60 to 100 cm and crop coefficient was changed due to environmental factors and any change in the K_C may affect directly the crop water use.

[15, 16, 17, 18 and 19] found that seasonal evapotranspiration (ET_C) of sunflower and water use efficiency WUE decreased by increasing available soil moisture depletion (ASMD) percentage.

MATERIAL AND METHODS

Two field experiments were conducted at the farm of Tameia Agric. Res. Station, Fayoum Governorate during the summer seasons of 2009 and 2010 to study the effect of sowing dates and irrigation scheduling treatments on sunflower yield, yield components and crop water relations. To achieve these targets three sowing date treatments, i.e. planting on D_1: 1st of June, D_2: 15th of June and $D_{3:}$ 1st of July, were combined with three irrigation scheduling treatments, i.e. irrigation at I_1: 0.8 cumulative pan evaporation C.P.E., I_2 1.0 C.P.E., and I_3: 1.2 C.P.E. in a split-plot design with four replications. The effect of different experimental treatments on seed yield, and yield component as well as crop water relations was studied. Calcium super phosphate at (15.5% P_2O_5) at the rate of 150 Kg was added during field preparation. Nitrogen fertilization (ammonium nitrate 33.5%N) at the rate of 30 Kg N/fed was added at two equal doses (at 1st and 2nd irrigations). Sunflowers (Sakha 53 cv.) were sown at the rate of 5 Kg /feddan in hills of 20cm apart during the two seasons, respectively. Application of irrigation scheduling treatments started from the 2nd irrigation. Seeds were harvested on 8th of September for the first sowing date, 15th for the second sowing date and 25th for the third ones in the two successive seasons. The soil physical and chemical properties of the experimental plots were determined according to [20 and 21] shown in Table (1). The monthly averages of climatic factors for Fayoum Governorate during the two growing seasons are shown in Table (2). The soil moisture constants of the experimental field (mean of the two seasons) are listed in Table (3). The soil moisture values were determined gravimetrically on oven dry basis, as the technique of Water Requirements and Field Irrigation Department, A.R.C., Egypt for different layers, each of 15.0 cm from soil surface and down to 60 cm depth. At harvesting time the following data were recorded for each sub-plot.

Yield and yield component;

1- Plant height (cm) 2- Head diameter (cm) 3- Head weight (gm)
4- Seed weight/head (gm) 5- 100 grain weight (gm) 6- Seed yield (Kg)/feddan

All the measurements and data collected were subjected to the statistical analysis according to the methods described by [22].

Crop water relations:

1. Seasonal consumptive use (ET_C)

For obtaining the crop water consumptive use (ET_C), soil samples were taken just before and 48 hours after each irrigation, as well as at harvest time. The crop water consumptive use between each two successive irrigations was calculated according to the following equation [23].

$$Cu = \frac{D.Bd.[Q2 - Q1]}{100}$$

Where:
CU = actual evapotranspiration.
D = the irrigation soil depth (cm).
Bd = bulk density of soil (g/cm^3).
Q_2 = the percentage of soil moisture two days after irrigation.
Q_1 = the percentage of soil moisture before next irrigation

2. Daily ET_C rate (mm/day). Calculated from the ET_C between each two successive irrigations divided by the number of days.

3. Reference evapotranspiration (ET_o)

Estimated as a monthly rate (mm/day), using the monthly averages of climatic factors of Fayoum Governorate and the procedures of the FAO-Penman Monteith equation [24]

4. Crop Coefficient (K_C).

The crop coefficient was calculated as follows:

$$K_C = ET_C / ET_o$$

Where: ET_C = Actual crop evapotranspiration and ET_o = Reference evapotranspiration.

Table (1): Physical and chemical analysis of the experimental field during 2008 and 2009 seasons (average of two seasons)

Physical properties					
Particle size distribution (%)				Organic matter %	$CaCo_3$ %
Sand	Silt	Clay	Texture		
38.00	21.2	40.8	Clay loam	1.68	5.18

Chemical analysis														
Soluble cations meq/L				Soluble anions meq/L				EC dS/m	pH 1:2.5 Extract	CEC Meq/ 100 gm soil	Exchangeable Cations Meq/100 gm soil			
Ca^{++}	Mg^{+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	CO_3^{--}	SO_4^{--}				Ca^{++}	Mg^{++}	K^{+}	Na^{+}
8.18	7.69	24.67	0.33	20.73	3.06	0.0	17.08	4.00	8.12	32.47	6.29	10.29	1.2	4.05

5. Water use efficiency (WUE).

Water use efficiency (kg/m^3) values for the different treatments were calculated by the following equation [25].

$$\text{WUE} = \text{Seed yield (kg/feddan)} / \text{Consumptive use (m}^3\text{/feddan)}$$

Table (2): The monthly averages of climatic factors for Fayoum Governorate during 2009 and 2010 seasons

Month	Year	Temperature C°			Relative Humidity %	Wind speed(m/sec)	Pan evaporation(mm/day)
		Max.	Min.	Mean			
June	2009	38.2	20.4	29.3	44	2.99	8.18
	2010	38.4	21.4	29.9	48	3.01	7.60
July	2009	38.5	22.7	30.6	47	2.58	8.41
	2010	36.3	22.4	29.3	50	2.58	8.60
August	2009	37.0	21.8	29.4	48	2.42	7.62
	2010	40.2	24.5	32.3	46	2.44	7.00
September	2009	35.2	20.7	27.9	50	2.58	6.69
	2010	36.2	21.9	29.1	50	2.60	6.10

Table (3): The average values of soil moisture constants of the experimental field at experimental site

Depth(cm)	Field capacity (%, w/w)	Wilting point (%, water)	Available water (mm)	Bulk density (g/cm^3)
0-15	42.46	21.06	21.4	1.41
15-30	40.73	19.81	20.92	1.43
30-45	38.12	18.55	19.57	1.31
45-60	33.55	17.32	16.23	1.39

RESULTS AND DESCUTION

Yield and yield components

Yield components

The results in Table (4) reveal that all yield components were significantly affected by sunflower sowing dates in both seasons. Sowing on June 1st gave the highest averages of yield components, whereas, the lowest ones were obtained from sowing on July 1st, in both seasons. Delaying sowing date from June 1st to July 1st significantly decreased plant height, head diameter, head weight, seed weight/head and 100-seed weight in 2009 season by 10.55, 12.13, 14.73, 22.33 and 15.34%, respectively, whereas, in 2010 season by 9.86, 11.41, 15.33, 23.60 and 16.17%, respectively. These results may be due to that delaying sowing date will reduce the vegetative and reproductive growth periods which in turn reduce dry matter accumulation in plant organs. These results are in agreement with those reported by [1, 2 and 3].

The data recorded in Table (4) show that the averages of sunflower yield components were significantly differ due to irrigation scheduling treatments in both seasons. Irrigation at 1.2 C.P.E. gave the highest averages of yield components, whereas, the lowest ones were detected from irrigation at 0.8 C.P.E. (long intervals). These results were found to be true in both seasons. It is obvious that increasing irrigation scheduling rate from 0.8 to 1.2 C.P.E. significantly increased plant height, head diameter, head weight, seed weight/head and 100-seed weight in 2009 season by 8.73, 10.11, 14.84, 13.74 and 9.87%, and in 2010 season by 8.60, 10.97, 14.59, 14.82 and 10.63%, respectively. These results may referred to the effect of water deficit, resulted from irrigation at long intervals (0.8 C.P.E. treatment), which in turn reduced plant growth and all yield component and consequently seed filling and weight. The results are in full agreement with those found by [8, 9, 10, 11 and 12].

Results in Table (4) indicate that sunflower yield components were significantly affected by the interaction between sowing dates and irrigation scheduling treatments in both seasons except plant height and head diameter in 2009 season, whereas, in 2010 season head diameter and seed weight/head were not significantly affected. The highest averages of yield components were detected from first sowing date and irrigation at 1.2 C.P.E.. However, the lowest averages were obtained from the third sowing date and irrigation at 0.8 C.P.E.

Seed yield (kg/feddan)

The results in Table (4) show those seed yield/feddan were significantly affected by sowing dates in both seasons. The highest seed yield i.e. 922.37 and 990.77 kg/feddan in 2009 and 2010 seasons, respectively, were resulted from the first sowing date (1^{st} June). However, delaying sowing date to (1^{st} July) gave the lowest averages of seed yield/feddan i.e. 624.03 and 657.33 kg/ feddan in the two successive seasons, respectively. On the other hand, delaying sowing date from 1^{st} to 15^{th} June reduced the seed yield by 16.11 and 17.19% in the first and second seasons, respectively. These results indicated that the highest yield recorded in first sowing date compared with late sowing (D_2 and D_3) maybe due to the fact that the crop gets sufficient time for its growth and development under suitable climatic conditions compared to late sowing. These results confirm the finding of [1 and 3].

The data presented in Table (4) reveal that irrigation scheduling treatments significantly affected seed yield/ feddan in both seasons. Irrigated sunflower plants at 1.2 C.P.E. gave the highest seed yield, i.e. 857.13 and 912.83 kg/ feddan, in the two successive seasons, respectively. On the other hand, irrigation at 0.8 C.P.E. gave the lowest seed yields, i.e. 691.23 in 2009 season, and in 2010 season was745.00 kg/feddan These results maybe referred to the effect of water deficit resulted from irrigation at long intervals (0.8 C.P.E.), which in turn reduced yield components and consequently seed yield. The results are in full agreement with those found by [11 and 12].

The results recorded in Table (4) indicate that the averages of seed yield were significantly affected by the interaction between sowing dates and irrigation treatments in both seasons. The first sowing date and frequent irrigations (1.2 C.P.E.) gave the highest average of seed yield in both seasons, i.e. 1050.1 and 1130.4 kg/fed, respectively. Whereas, the lowest averages, i.e. 560.7 and 596.2 kg/ feddan were obtained from third sowing date and irrigation at 0.8 C.P.E. in 2009 and 2010 seasons, respectively.

Crop water relations:

Seasonal Consumptive Use (ET_C)

The results in Table (5) show that the values of seasonal consumptive use (ET_C) of sunflower crop, as a function of sowing date and irrigation scheduling treatment were 47.76 and 49.86 cm in 2009 and 2010 seasons, respectively. Delaying sowing date from 1^{st} June to 15^{th} and 1^{st} July decreased seasonal ET_C by 5.20 and 12.81% in 2009 season, and by 4.12 and 12.19% in 2010 season, respectively. Such results may by due to the reduction in evapotranspiration which related to reduce the long season of growth. These results are in the same trend with the results previously reported by [6], [19], [7] and [4].

The data recorded in Table (5) reveal that irrigation at 1.2 C.P.E. gave the highest values of seasonal ET_C, i.e. 50.06 and 52.47 cm in the two successive seasons. Whereas, the lowest ET_C values, i.e. 45.55 and 47.36 cm in the two successive seasons, were resulted from irrigation at 0.8 C.P.E.(long intervals). Decreasing irrigation intervals from irrigation at 0.8 to 1.0 or 1.2 C.P.E. increased seasonal ET_C in 2009 season by 4.45 or 9.01%, and in 2010 season by 4.80 or 9.74%, respectively.

Table (4) Yield and yield components of sunflower as affected by sowing dates, irrigation scheduling treatments and their interaction in 2009 and 2010 seasons

Treatments		**2009**						**2010**					
Sowing dates	Irrig. Sched. C.P.E.	Plant Height (cm)	Head Diameter (cm)	Head Weight (gm)	Seed Weight/ Head(gm)	100-seed Weight (gm)	Seed yield/fed (kg)	Plant Height (cm)	Head Diameter (cm)	Head Weight (gm)	Seed Weight/ Head(gm)	100-seed Weight (gm)	Seed yield/fed (kg)
D_1 1/6	I_1: 0.8	161.6	17.20	241.40	100.4	7.02	812.4	170.20	17.50	247.80	102.30	7.11	890.60
	I_2:1.0	169.3	18.00	255.60	111.6	7.74	904.6	179.60	18.10	262.70	114.10	7.86	951.30
	1_3: 1.2	178.2	19.20	274.80	119.3	7.92	1050.1	185.00	19.60	281.90	126.00	8.21	1130.40
	Mean	**169.7**	**18.13**	**257.27**	**110.43**	**7.56**	**922.37**	**178.27**	**18.40**	**264.13**	**114.13**	**7.73**	**990.77**
D_2 15/6	I_1: 0.8	155.8	16.50	220.70	89.20	6.40	700.60	164.80	16.50	219.90	91.60	6.47	748.20
	I_2:1.0	160.7	17.10	238.90	95.60	6.75	790.30	171.20	17.90	242.10	96.30	6.81	815.70
	1_3: 1.2	167.4	18.30	265.10	99.20	6.94	830.50	176.30	18.60	269.00	100.40	7.00	897.60
	Mean	**161.3**	**17.30**	**241.57**	**94.67**	**6.70**	**773.80**	**170.77**	**17.67**	**243.57**	**96.10**	**6.76**	**820.50**
D_3 1/7	I_1: 0.8	143.6	15.10	202.70	78.70	6.01	560.70	150.30	15.40	209.10	79.10	6.11	596.20
	I_2:1.0	152.1	15.90	214.60	86.10	6.46	620.60	162.10	16.20	220.6	88.40	6.50	665.30
	1_3: 1.2	159.7	16.80	240.80	92.50	6.72	690.80	169.70	17.30	241.20	94.10	6.82	710.50
	Mean	**151.8**	**15.93**	**219.37**	**85.77**	**6.40**	**624.03**	**160.70**	**16.30**	**223.63**	**87.20**	**6.48**	**657.33**
Irrig. mean	I_1: 0.8	153.7	16.27	221.60	89.43	6.48	691.23	161.77	16.47	225.50	91.00	6.56	745.00
	I_2:1.0	160.7	17.00	236.37	97.77	6.98	771.83	170.97	17.40	241.80	99.60	7.06	810.77
	1_3: 1.2	168.4	18.10	260.23	103.67	7.19	857.13	177.00	18.50	264.03	106.83	7.34	912.83
L.S.D: at 0.05													
	D	1.05	0.29	4.17	0.49	0.23	18.98	1.49	0.29	3.36	3.86	0.10	15.75
	I	2.01	0.25	2.22	1.25	0.06	27.93	1.78	0.27	2.58	4.35	0.14	15.41
	D x I	N.S	N.S	3.14	1.76	0.09	39.50	3.09	N.S	4.47	N.S	0.24	26.69

These results may be attributed to that irrigation at 1.2 C.P.E. (frequent irrigation) increased the available soil moisture in the root zone of plants and this maybe increased the transpiration process from the plant vegetation. These results are in harmony with those found by [15-19].

Regarding the effect of interaction, data recording in Table (5) indicate that the first sowing date and irrigation at 1.2 C.P.E. gave the highest value of seasonal ET_C in the two successive seasons, i.e. 53.19 and 55.43 cm, respectively. While the third sowing date and irrigation at 0.8 C.P.E. gave the lowest value of seasonal ET_C, i.e. 42.18 and 44.19 cm, in the two successive seasons, respectively.

Table (5): Effect of sowing dates and irrigation scheduling on seasonal consumptive use of sunflower crop (ET_C) in cm

Sowing dates	2009			Mean	2010			Mean
	0.8	1.0	1.2		0.8	1.0	1.2	
D_1 (1/6)	48.37	50.86	53.19	**50.81**	50.18	52.58	55.43	**52.73**
D_2 (15/6)	46.10	48.18	50.24	**48.17**	47.72	50.39	53.57	**50.56**
D_3 (1/7)	42.18	43.98	46.74	**44.30**	44.19	46.28	48.42	**46.30**
Mean	**45.55**	**47.67**	**50.06**	**47.76**	**47.36**	**49.75**	**52.47**	**49.86**

Daily ET_C rate (mm/day).

The data listed in Table (6) generally, indicated that the daily ET_C rate, as a mean of the different treatments under this study started with low values during June, i.e. 3.80 and 3.91 mm/day in 2009 and 2010 seasons, respectively. Thereafter, the daily ET_C rate increased during July and reached its maximum values during August (6.42 and 6.80 in the two successive seasons) and decline again during September (harvesting). Such findings may be attributed to that during June most of water losses were caused by evaporation from the bare soil (germination and seedling stages). Thereafter, as the crop cover increased the daily ET_C increased because transpiration took place beside evaporation and reached the peak rate at flowering and grain filling stages, the ET_C rate re-decreased during September as a result of lower leaves drying and low transpiration rate.

Results in Table (6) showed that using ammonium nitrate decreased the daily ET_C during the months of grain sorghum growing season duration from June until September in both seasons.

The presented data in Table (6) revealed that irrigating grain sorghum at 1.2 C.P.E (frequent irrigation) increased the daily ET_C rate during the growing season, in both seasons. However, irrigation at 0.8 C.P.E gave the lowest results, these results may be attributed to the high available moisture in the root zone resulted from short irrigation intervals (frequent irrigation), which in turn increased the evapotranspiration rate during the growing season months. Similar results were obtained by [13 and 14].

Reference evapotranspiration (ET_o)

The daily ET_0 rates during grain sorghum growing season in 2009 and 2010 seasons are presented in Table (7). The daily ET_o values (mm/day) were calculated using the FAO-Penman-Monteith equation and meteorological data of Fayoum Governorate (Table, 2). From June to September in both growing seasons. The obtained results in Table (7) indicate that the daily ET_o rates started with high values during June and slowly decreased during July with continuous decrease during August and September, in both seasons. These results can be attributed to the changes in climatic factors from month to the other. In this connection, [24], reported that the values of ET_o are depend mainly on the evaporative power of the air (temperature, humidity and wind speed).

Table (6): Effect of sowing dates, irrigation scheduling treatments and their interaction on daily water consumption use (mm/day) in seasons 2009 and 2010

reatment		2009				2010			
		June	**July**	**August**	**Sep.**	**June**	**July**	**August**	**Sep.**
D_1 1/6	**0.8**	3.4	5.06	6.41	3.26	3.57	5.29	6.55	3.46
	1.0	3.57	5.37	6.69	3.45	3.74	5.53	6.84	3.77
	1.2	3.66	5.77	6.84	3.90	3.74	5.77	7.40	4.23
	Mean	**3.54**	**5.40**	**6.65**	**3.54**	**3.68**	**5.53**	**6.93**	**3.82**
D_2 15/6	**0.8**	3.99	4.82	6.12	3.87	3.9	5.23	6.44	4.03
	1.0	4.08	5.14	6.41	3.90	4.07	5.30	6.81	4.23
	1.2	4.08	5.60	6.55	4.03	4.4	5.69	7.18	4.42
	Mean	**4.05**	**5.19**	**6.36**	**3.93**	**4.12**	**5.41**	**6.81**	**4.23**
D_3 1/7	**0.8**	-	4.42	5.83	4.16	-	4.60	6.29	4.49
	1.0	-	4.42	6.26	4.35	-	4.60	6.66	4.55
	1.2	-	4.66	6.70	4.61	-	4.76	7.03	4.75
	Mean	**-**	**4.50**	**6.26**	**4.37**	**-**	**4.65**	**6.66**	**4.60**
Mean of Irrig.									
0.8		3.70	4.77	6.12	3.76	3.74	5.04	6.43	3.99
1.0		3.83	4.98	6.45	3.90	3.91	5.14	6.77	4.18
1.2		3.87	5.34	6.70	4.18	4.07	5.41	7.20	4.47
Over mean		**3.80**	**5.03**	**6.42**	**3.95**	**3.91**	**5.20**	**6.80**	**4.21**

Crop Coefficient (K_C).

The crop coefficient reflects the crop cover percentage and soil conditions on the ET_o values. The K_C values were estimated from the daily ET_C rates (Table 6) and the daily ET_o rates (Table 7) during the two growing seasons. The results in Table (7) reveal that the K_C values, as a function of the interaction between sowing dates and irrigation scheduling treatments (as overall mean) were low during June (initial growth period). Then increased during July (vegetative growth period) and reached its maximum values during August (flowering-head formation). Thereafter, the K_C values redecreased again during September (seed-filling-maturity and harvesting). These results were found to be true in 2009 and 2010 seasons. Such finding may be due to the large diffusive resistance of bare soil at the initial growth period, which decreased by the increase in crop cover percentage until maximum growth (flowering and seed formation). However, at maturity (late season) transpiration rates decreased, as most plant leaves dried.

Finally, the K_C values of sunflower for high production were 0.43, 0.73, 0.95 and 0.61 in 2009 season, and 0.45, 0.74, 1.00 and 0.65 in 2010 season, during June, July, August and September, respectively, under (D_1I_3) treatments.

Water Use Efficiency (WUE)

The results presented in Table (8) clearly show that the mean values of WUE, as a function of different tested treatments, were 0.383 and 0.390 kg seeds/m^3 water consumed in 2009 and 2010 seasons, respectively. The highest values of WUE i.e. 0.431 and 0.447 kg seeds/m^3 water consumed were detected from the first sowing date.

Data listed in Table (8) indicate that irrigation at 1.2 C.P.E. gave the highest WUE values, i.e. 0.405 and 0.411 kg seeds/ m^3 water consumed in 2009 and 2010 seasons, respectively. [18 and 19].

Data in Table (8) show that the highest WUE values i.e. 0.470 and 0.486 kg seeds/m^3 water consumed were obtained from (D_1I_3) in the two successive seasons, respectively.

Table (7): Reference evapotranspiration, ET_o (mm/day) and K_C for sunflower crop during 2009 and 2010 seasons as affected by sowing dates and irrigation scheduling treatments.

Sowing dates	Irrig. Sched. (C.P.E.)	2009 June	2009 July	2009 Aug.	2009 Sept.	2010 June	2010 July	2010 Aug.	2010 Sept.
Reference ET_o (mm/day)		8.5	7.9	7.2	6.4	8.3	7.8	7.4	6.5
D_1 1/6	0.8	0.40	0.64	0.89	0.51	0.43	0.68	0.89	0.53
	1.0	0.42	0.68	0.93	0.54	0.45	0.71	0.92	0.58
	1.2	0.43	0.73	0.95	0.61	0.45	0.74	1.00	0.65
	Mean	**0.42**	**0.68**	**0.92**	**0.55**	**0.44**	**0.71**	**0.94**	**0.59**
D_2 15/6	0.8	0.47	0.61	0.85	0.60	0.47	0.64	0.87	0.62
	1.0	0.48	0.65	0.89	0.61	0.49	0.68	0.92	0.65
	1.2	0.48	0.71	0.91	0.63	0.53	0.73	0.97	0.68
	Mean	**0.48**	**0.66**	**0.88**	**0.61**	**0.50**	**0.68**	**0.92**	**0.65**
D_3 1/7	0.8	-	0.56	0.81	0.65	-	0.57	0.84	0.67
	1.0	-	0.56	0.87	0.68	-	0.59	0.90	0.70
	1.2	-	0.59	0.93	0.72	-	0.61	0.95	0.73
	Mean	**-**	**0.57**	**0.87**	**0.68**	**-**	**0.59**	**0.90**	**0.70**
Mean of irrigation									
0.8		0.44	0.60	0.85	0.59	0.45	0.63	0.87	0.61
1.0		0.45	0.63	0.90	0.61	0.47	0.66	0.91	0.64
1.2		0.46	0.68	0.93	0.65	0.49	0.69	0.97	0.69
Over all mean		**0.45**	**0.64**	**0.89**	**0.62**	**0.47**	**0.66**	**0.92**	**0.65**

Table (8): Effect of sowing dates, irrigation scheduling treatments and their interaction water use efficiency of sunflower in 2009 and 2010 seasons

Treatments	2009				2010			
Sowing dates	Irrigation scheduling (C.P.E.)				Irrigation scheduling (C.P.E.)			
	0.8	1.0	1.2	Mean	0.8	1.0	1.2	Mean
D_1 1/6	0.400	0.424	0.470	0.431	0.423	0.431	0.486	0.447
D_2 15/6	0.362	0.391	0.394	0.382	0.373	0.385	0.399	0.386
D_3 1/7	0.317	0.336	0.352	0.335	0.321	0.342	0.349	0.337
Mean	0.360	0.384	0.405	0.383	0.372	0.386	0.411	0.390

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