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EFFECT OF SOME AGRICULTURAL PRACTICES ON PRODUCTIVITY AND WATER USE EFFICIENCY FOR SUNFLOWER

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ABSTRACT: ***Two field experiments were carried out during 2003 and 2004 seasons at Giza agricultural research farm. Three irrigation regimes, born due to scheduling the irrigation at 0.8, 1.0 and 1.2 coefficients for daily pan evaporation records , three sowing dates i.e. June, 23, July,7 and July,21 and two treatments of nitrogen fertilizers e.g. nitrogen fertilizer and/or biofertilizer were studied to select the effective combination of such treatments enhancing growth, yield and yield components and some water-crop relations of sunflower crop. The results revealed that, regarding all the adopted treatments, water consumptive use for sunflower reached 1652 and 1482 m^3/fed in the first and second season, respectively. Scheduling the irrigation at evaporation pan coefficient of 1.2 was superior to increase growth, yield and yield components traits of sunflower. At Giza area, it is advisable to calculate the potential evapotranspiration for sunflower crop using pan evaporation method because ETp and actual ETcrop values were closed to each other. Sowing sunflower crop on June, 23(early sowing date) exhibited higher values with regard to growth, yield and yield components attributes. The recommended nitrogen fertilizer dose + seed treating with bio-fertilizer was effective to increase growth, yield and its components more than nitrogen fertilizer alone. The highest water use efficiency and all of the investigated characters as well were recorded due to the combination of scheduling the irrigation at 1.2 evaporation pan coefficient + sowing on early date (June, 23) + applying the recommended nitrogen fertilizer dose plus treating the seeds with the bio-fertilizer (Cerealin).***

***Key words :** Sunflower, irrigation scheduling , sowing date, N-fertilization, biofertilizer.*

INTRODUCTION

Tremendous efforts should be implemented to mitigate the shortage in water resources and oil production as problems facing Egypt at the present conditions. Different ways have been proposed to improve the effective agricultural practices resulting in higher production of sunflower oil yield such as the proper of irrigation scheduling, sowing dates and nitrogen treatments. In addition, sunflower was chosen in the present study due to its

strategic value as the second oil crop in the world followed to soybean. Kramer (1983) found that decreasing soil moisture content is accompanied by loss of plant wilting, cessation of cell enlargement, stomatal closure, photosynthesis reduction and interference with many basic metabolic processes. El-Samanody . (2004) mentioned that seed weight/plant, 100-seed weight, seed yield and biological yields for sunflower were significantly increased by increasing available soil moisture before irrigation time (scheduling the irrigation according to 1.4 coefficient for pan evaporation records). Thosar . (1991) found that irrigation of sunflower at 75, 90, 105 and 120 mm cumulative daily pan evaporation records gave seed yields of 0.92-1.92, 0.85-1.12, 0.81-0.90 and 0.75- 0.79 t/ha, respectively. Vivek (1992) indicated that the average of sunflower seed yield was increased with increasing irrigation water (IW) : cumulative pan evaporation (CPE) ratio from 0.3 up to 0.9. Furthermore, Pawar .(1993) found that irrigation of sunflower at cumulative pan evaporation levels of 50, 75, 100 and 125 mm gave seed yields of 1.37, 1.27, 1.19 and 1.02 t/ha, respectively. Ali . (1998) indicated that head diameter, number of filled seeds per head and 100-seed weight for sunflower were significantly affected by irrigation frequencies, and the highest seed yield of 3119 kg/ha was obtained with six irrigations compared to 2200 kg/ha with two irrigations. Kumar and Rao (2001) studied the response of sunflower to evapotranspiration deficits imposed at specific crop growth sub-periods i.e. vegetative, flowering, seed formation and seed filling, and found that the crop in fully irrigated treatment recorded the highest seed yield (2767 kg/ha). Optimum sowing date appears to be among the most important factors which play a significant role to influence sunflower yield. Abelardo . (2002) found that sunflower yields are strongly reduced when normal sowing date was delayed. Moreover, Allam . (2003) reported that early planting date exerted highly significant increase on all vegetative growth, yield and its components attributes. In addition, Barros . (2004) found that an early sowing date let to simultaneous increase of leaf area index and the number of seeds/area without decreasing its weight and resulting in higher crop yield. Nitrogen is an essential element for the growth and development of the crops including sunflower. Many reports indicated that increasing the nitrogen rates increased leaf area index, seeds weight/plant, 100 seed weight, seed yield of sunflower (Faizani ., 1996; Wagh., 1992 and Jaybhaye ., 1992). Moreover, Conick .(1989); Zaki .(1992) and Keshta. (2000) reported that inoculation with N2–Fixing bacteria significantly enhanced head diameter, seed yield/fed and 100-seed weight for sunflower. In connection, Zaki ., (1992) found that biofertilization as a mixture of N2-fixing bacteria (Azospirillum, Bacillus and Azotobacter) added to the soil with different levels of mineral nitrogen fertilizers for wheat plant, could compensate considerable parts of mineral nitrogen fertilizer by about 2/3 and 1/3 of the recommended nitrogen rates in old and new lands.

The aim of this study is to investigate the effect of irrigation regimes (born due to different coefficients for daily records of pan evaporation), sowing dates and nitrogen fertilizers treatments on sunflower productivity and some crop-water relations.

MATERIALS AND METHODS

Two field experiments were conducted at Giza Agricultural Research Station farm during the two successive seasons 2003 and 2004. Some soil moisture constants for the experimental site and meteorological data of Giza region are presented in Tables (1) and (2), respectively. The study aimed to find out the effect of irrigation scheduling using different coefficients of daily pan evaporation records, sowing dates and nitrogen fertilizer treatments on growth, yield and yield components of sunflower crop variety Vudic and some crop-water relations. Therefore, a split-split plot design was used with four replicates. The main plots were devoted to irrigation regimes and sub–plots were assigned for the sowing dates, while sub-sub plots were occupied by the nitrogen fertilizer treatments. The sub-sub plot area was 21 m^2 (1/200 fed).

The adopted experimental treatments were as follows:

A- Irrigation regimes: (according to pan evaporation coefficients) of :

1- **(I_1) Irrigation at 1.2 evaporation pan coefficient.**
2- **(I_2) Irrigation at 1.0 evaporation pan coefficient .**
3- **(I_3) Irrigation at 0.8 evaporation pan coefficient ,**

B –Sowing dates:

1- **(D_1) (June 23): as early sowing date.**
2- **(D_2) (July 7): as intermediate sowing date.**
3- **(D_3) (July 21): as late sowing date .**

C- Nitrogen fertilizer treatments:

1- **Nitrogen fertilizer, the recommended rate(30 kg N/fed) as Ammonium Nitrate, 33.5% N was applied in two equal doses before mohayah and the next irrigations.**
2- **(N2) The recommended N fertilizer rate + bio-fertilizer (100 g of ceraline was thoroughly mixed with 5 kgs of seed 30 minutes before sowing).**

Table (1): Some soil moisture constants and bulk density for the experimental site at Giza farm.

Depth(cm)	Field capacity (%, by weight)	Wilting point (%,by weight)	Available water (mm)	Bulk density g/cm^3
00 - 15	41.85	18.61	40.1	1.15
15 - 30	33.68	17.50	30.1	1.24
30 - 45	28.36	16.92	20.6	1.20
45 - 60	28.05	16.54	22.1	1.28

Table(2):Some meteorological data for Giza region in 2003 and 2004 seasons.

Month	2003 season						
	T.max (ºC)	T.min (ºC)	W.S. (m/s)	R.H. (%)	S.S. (h)	E. pan (mm/month)	S.R. (cal/cm^2/day)
June	34.9	21.8	2.2	56	12.0	9.7	627
July	38.1	28.1	1.9	58	11.7	8.4	613
August	35.6	24.6	1.7	63	11.1	7.1	577
September	35.9	23.3	1.6	58	10.1	5.7	512
October	30.3	20.2	3.0	52	9.2	4.2	417
2004 season							
Month	T.max (ºC)	T.min (ºC)	W.S. (m/s)	R.H. (%)	S.S. (h)	E. pan (mm/month)	S.R. (cal/cm^2/day)
June	34.4	23.0	3.5	44	12.0	8.2	627
July	33.5	25.3	3.3	46	11.7	7.9	613
August	34.1	24.6	3.3	48	11.1	6.3	577
September	32.9	23.8	4.2	56	10.1	5.3	512
October	30.5	20.7	3.7	50	9.2	5.0	417

T. max= Maximum temperature; T.Min=Minimum temperature; W.S.=Wind speed; R.H.=Relative humidity; S.S.=Actual sunshine duration; E. pan = Evaporation pan; S.R.= Solar radiation.

Irrigation date was determined according to sum daily records of the pan evaporation multiplying by the tested coefficient as the two sides of the following formula became the same :-

Available soil moisture in soil profile (mm) = Cumulative daily pan evaporation records (mm) X coefficient

All of the other agronomic practices i.e. plant density, weed control .etc were carried out as recommended for sunflower production. Harvest took place in Sep, 24, October, 8 and October, 23 for early, intermediate and late sowing dates in the two growing seasons, respectively.

The studied parameters were as follows:

I- Growth, yield and yield component parameters:

1- Leaf area index.
2- Seeds weight/plant (g)
3- 100-seed weight (g)
4- Biological yield (kg/fed)
5-Seed yield (kg/fed)

I I- Crop-water relation parameters:

I I-1-Seasonal actual water consumptive use (evapotranspiration)

Actual evapotranspiration (ET) was estimated by the soil sampling just before and 48 hrs after each irrigation, besides at harvest and calculated according to the equation of Israelsen and Hansen (1962) as follows:

$$CU = \frac{(\Theta_2 - \Theta_1) \times Bd \times 60 \times 4200}{100 \times 100}$$

Where:
CU= water consumptive use in m^3/fed.
Θ_2= soil moisture percentage by weight 48 hrs after irrigation.
Θ_1= soil moisture percentage by weight 48 hrs before next irrigation.
Bd= bulk density in g/cm^3

I I-2- Water Use Efficiency (WUE)

Water use efficiency values were calculated as (kg/m^3) for different treatments according to the following equation (Vites, 1965).

$$WUE, kg/m^3 = \frac{\text{Seed yield (kg/fed)}}{\text{Water consumptive use } (m^3/\text{fed})}$$

I I -3- Monthly water consumptive use:

Monthly values were obtained from daily water use multiplied by the number of days in the month.

I I -4- Sunflower potential evapotranspiration

Potential evapotranspiration values (ETp) were estimated by four empirical formulae Viz. Modified Penman, Penman Monteith, Doorenbos-Pruitt and Evaporation pan. The “ WATER “ model (Zazueta and Smajstria, 1984) was used to calculate potential evapotranspiration by the Modified Penman, Doorenbos-Pruitt and Evaporation pan method, while, “CROPWAT “ model (Smith, 1991) was used for calculation the potential evapotranspiration by Penman Monteith method.

I I-5- Comparison with actual ET:

Crop evapotranspiration values estimated by Modified Penman, Penman Monteith, Doorenbos-Pruitt and Evaporation pan methods were compared with the actual ET crop to clarify the efficiency of these impiricl methods in calculating the ET crop values.

Statistical Analysis

Data of leaf area index, yield and its components were subjected to statistical analysis as described by Snedecor and Cochran, 1980.

RESULTS AND DISCUSSION

A- Growth, yield and its components

1-Effect of irrigation regimes:

1-1 Growth:

Data presented in Table (3) indicated that no significant differences were observed on leaf area index as influenced by different irrigation treatments, however the values tended to increase as irrigation regimes increased during the two growing seasons. Values of LAI were 3.57, 3.52 and 2.94 as irrigation was scheduled according to 1.2, 1.0 and 0.8 pan evaporation coefficients, in the first season, respectively. Whereas, in the second season the values comprised 3.69, 2.93 and 2.89 for the same respective of irrigation regimes. These findings may be due to the effect of the available soil moisture prevailing throughout the growing season, since El-Samanody (2004) come to the same results and justifications.

Table (3): Effect of irrigation regimes on some growth, yield and yield components parameters of sunflower crop during 2003 & 2004 seasons.

Irrigation regimes	L.A.I		Seed weight/ plant (g)		100 - seed weight (g)		Seed yield (kg/ fed)		Biological yield (kg/fed)	
	2003	2004	2003	2004	2003	2003	2004	2003	2004	2003
1.2	3.57	3.69	56.89	52.49	6.27	6.33	1153.3	1077.1	4003.3	4244.2
1.0	3.52	2.93	52.58	50.04	5.93	6.11	984.5	958.3	3573.7	3595.1
0.8	2.94	2.89	48.85	46.53	5.63	5.59	823.1	829.2	3139.2	2919.0
L.S.D.	N.S	N.S	4.13	3.87	N.S	0.22	112.41	106.79	N.S	219.24

I-2 Seed yield and yield components:

Seed and biological yields besides seeds weight/plant, and 100-seed weight were increased as irrigation was scheduled at 1.2 evaporation pan coefficient, compared to the other two irrigation regimes in both seasons (Table 3). The differences reached the level of significance with all traits, except 100-seeds weight and biolgical yield in first season only. Seed yield was increased in the 1st season, due to scheduling irrigation according to 1.2 pan evaporation coefficient by 17.15 and 40.12 %, comparable with 1.0 and 0.8 pan evaporation coefficients, respectively. The same trend was observed in the 2nd season with increase percentage comprised 12.40 and 29.90 % in

the same order. The obtained results are in parallel with those obtained by Vivek (1992), Ali ., (1998) and El-Samanody ., (2004).

2- Effect of sowing dates:

The results presented in Table (4) indicated that the differences between the adopted sowing dates were significant for leaf area index, seed yield and yield components traits in both seasons. The early sowing date gave the maximum values for leaf area index, seeds weight/plant, 100-seeds weight, seed yield/fed and biological yield/fed in both seasons, comparable with intermediate and late ones. The increase in seed yield, due to sowing on early date, reached 31.0 and 76.39 % in the 1st season and 40.12 and 34.17 % in the 2nd season, as compared to those under intermediate and late sowing dates, respectively. The present results are in agreement with those obtained by Abelardo, ., (2002), Allam . (2003) and Barros . (2004).

Table (4): Effect of sowing dates on some growth parameter, yield and yield components on Sunflower crops during 2003 & 2004 seasons.

Sowing dates	L.A.I		Seed weight/ plant (g)		100 - seed weight (g)		Seed yield (kg/ fed)		Biological yield (kg/fed)	
	2003	2004	2003	2004	2003	2003	2004	2003	2004	2003
D_1	4.30	4.08	65.95	65.02	6.80	6.97	1271.5	1283.8	4298.9	4125.9
D_2	3.13	3.07	51.21	47.34	5.81	5.95	970.6	916.2	3672.6	3578.8
D_3	2.60	2.36	41.17	36.71	5.23	5.11	718.8	664.6	2744.7	3053.6
L.S.D.	0.54	0.78	7.55	6.18	0.35	0.25	134.19	95.85	447.02	354.71

3- Effect of nitrogen treatments:

The results presented in Table (5) pointed out that the differences between the N fertilizer treatments were significant for seed weight/plant, 100-seed weight in both seasons. The values were (3.25-3.44), (50.72-54.83 g), (5.77-6.12 g) and (3371.4-3772.6 kg/fed) for leaf area index, seed weight/plant, 100-seed weight and biological yield for N fertilizer alone and N fertilizer as combined with bio-fertilizer in the 1st growing season, respectively. In the second season, the values reached to (3.06-3.28), (47.70-51.86 g), (5.82-6.20 g) and (3475.4-3696.3 kg/fed) for the same respective of N fertilizer treatments and crop characters. The results showed that the N fertilizer as combined with bio-fertilizer maximized seed yield, compared with single nitrogen fertilizer, since the increases reached 7.67 and 10.70% in the first and second season, respectively. These results are go to support those of Wagh . (1992) and Zaki . (1992) who found that bio-fertilization as combined with mineral nitrogen fertilizers could compensate considerable parts of mineral nitrogen fertilizer reached to 2/3 or 1/3 of the recommended dose of nitrogen under different soil types.

Table (5): Effect of nitrogen treatments on some growth parameter, yield and yield components on sunflower crops during 2003 & 2004 seasons

Nitrogen treatments	L.A.I		Seed weight/ plant (g)		100 - seed weight (g)		Seed yield (kg/ fed)		Biological yield (kg/fed)	
	2003	2004	2003	2004	2003	200٤	2003	2004	2003	2004
F_1	3.25	3.06	50.72	47.70	5.77	5.82	950.5	906.3	3371.4	3475.4
F_2	3.44	3.28	54.83	51.86	6.12	6.20	1023.4	1003.4	3772.6	3696.3
F-test	N.S.	N.S.	Sig.	Sig.	Sig.	Sig.	N.S.	Sig.	Sig.	N.S.

4- Interaction between irrigation regimes, sowing dates and nitrogen fertilizer treatments:

Although no significant differences were obtained due to the interaction of irrigation regimes, sowing dates and nitrogen treatments, Table (6) the results cleared that leaf area index, yield and yield components were superior with the combination of irrigation at 1.2, early sowing date (D1) and N fertilizer + biofertilizer (F1). These results were in harmony with the results obtained by keshta . (2000) and El-Samanody . (2004), where they indicated that increasing the available soil moisture, sowing sunflower early and applying N fertilizer + biofertilizer increased the seed yield and 100-seed weight values.

Table (6): Effect of the interaction between irrigation regimes , sowing dates and nitrogen treatments on growth , yield and yield components of sunflower in 2003 & 2004 seasons

Treatments			L.A.I		Seed weight/ plant (gm)		100 - seed weight (gm)		Seed yield (kg/ fed)		Biological yield (kg/fed)	
			2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
1.2	D_1	F_1	5.21	3.69	64.43	63.63	6.69	6.81	1431.0	1301.3	4272.3	4748.0
		F_2	4.16	6.16	73.77	74.77	7.71	7.88	1473.7	1568.7	5117.3	5029.7
	D_2	F_1	2.53	4.08	55.97	48.07	5.97	6.32	1221.7	929.0	3822.7	4353.7
		F_2	3.67	3.18	58.50	51.07	6.20	6.29	1181.0	1127.3	4196.3	4058.0
	D_3	F_1	2.84	2.46	42.90	36.87	5.30	5.25	748.0	723.0	3059.3	3356.0
		F_2	3.03	2.58	45.80	40.57	5.77	5.46	864.7	813.3	3551.7	3919.7
1.0	D_1	F_1	4.48	3.80	67.13	59.57	6.31	6.72	1228.3	1253.3	4059.3	4159.0
		F_2	4.28	3.87	68.63	69.27	7.74	7.58	1343.0	1321.3	4504.3	4209.3
	D_2	F_1	3.46	2.55	50.37	45.53	5.68	6.24	897.3	913.3	3624.7	3518.3
		F_2	3.59	2.74	46.80	52.57	5.58	5.91	970.0	965.3	3808.7	3572.7
	D_3	F_1	2.57	1.93	38.33	37.60	4.91	4.84	690.3	594.7	2448.7	2688.7
		F_2	2.74	2.68	44.23	35.70	5.36	5.35	778.0	702.0	2996.3	3422.7
0.8	D_1	F_1	3.46	3.79	59.37	58.47	6.28	6.27	1045.7	1135.3	3823.7	3321.3
		F_2	4.21	3.16	62.37	64.40	6.05	6.58	1107.3	1122.7	4016.7	3288.0
	D_2	F_1	2.61	2.94	44.90	43.93	5.69	5.31	732.3	773.7	3159.3	2900.0
		F_2	2.92	2.93	50.73	42.90	5.75	5.60	821.0	788.7	3424.0	3070.3
	D_3	F_1	2.07	2.27	33.07	35.60	5.11	4.57	560.0	533.3	2073.0	2234.0
		F_2	2.35	2.23	42.67	33.90	4.92	5.17	672.0	621.3	2338.3	2700.3
L.S.D			N.S	1.33	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

B- Crop-Water relations:

1- Seasonal actual water consumptive use (ETa):

Seasonal actual consumptive use (ETa) as affected by irrigation regimes, sowing dates, nitrogen fertilizer treatments and their interactions are recorded in Table (7). The values of ETa respective to all the adopted treatments together reached 1652 and 1482 m^3/fed in 2003 and 2004 seasons, respectively. Differences between ETa values may be due to the variation in weather condition, especially air temperature, prevailing through the two growing seasons

Table (7): Seed yield (kg/ fed), W.C.U. (m^3/fed) and W.U.E (kg seeds/m^3 onsumed water) for sunflower crop in 2003 & 2004 seasons .

Treatments			Seed yield (kg/ fed)		W.C.U. (m3/fed)		W.U.E. (kg seeds/m3)	
			2003	2004	2003	2004	2003	2004
1.2	D1	F1	1431.0	1301.3	2122	2093	0.67	0.62
		F2	1473.7	1568.7	2245	2104	0.66	0.75
	D2	F1	1221.7	929.0	1854	1685	0.66	0.55
		F2	1181.0	1127.3	1962	1712	0.60	0.66
	D3	F1	748.0	723.0	1344	1321	0.56	0.55
		F2	864.7	813.3	1489	1393	0.58	0.58
Average			1153.3	1077.1	1836	1718	0.63	0.63
1.0	D1	F1	1228.3	1253.3	2050	1615	0.60	0.78
		F2	1343.0	1321.3	2106	1803	0.64	0.73
	D2	F1	897.3	913.3	1508	1353	0.60	0.68
		F2	970.0	965.3	1635	1378	0.59	0.70
	D3	F1	690.3	594.7	1279	1188	0.54	0.50
		F2	778.0	702.0	1310	1393	0.59	0.50
Average			984.5	958.3	1648	1455	0.60	0.66
0.8	D1	F1	1045.7	1135.3	1874	1605	0.56	0.71
		F2	1107.3	1122.7	1934	1615	0.57	0.70
	D2	F1	732.3	773.7	1382	1127	0.53	0.69
		F2	821.0	788.7	1483	1174	0.55	0.67
	D3	F1	560.0	533.3	1052	1037	0.53	0.51
		F2	672.0	621.3	1108	1093	0.61	0.57
Average			823.1	829.2	1472	1275	0.56	0.65
Average for all		D1	1271.5	1283.8	2055	1809	0.62	0.71
		D2	970.6	916.2	1637	1405	0.59	0.65
		D3	718.8	664.6	1264	1238	0.57	0.54
		F1	950.5	906.3	1607	1447	0.59	0.63
		F2	1023.4	1003.4	1697	1518	0.60	0.66

As for irrigation regimes, ETa values in 2003 season were 1836, 1648 and 1472 m^3/fed under 1.2, 1.0 and 0.8 evaporation pan coefficients, respectively. The same respective values in 2004 season were 1718, 1455 and 1275 m^3/fed. These results indicate that ETa was increased as the available soil moisture increased in the root zone of plants (irrigation sunflower plants at shorter irrigation intervals i.e. irrigating at 1.2 pan evaporation coefficient). While extended the period between irrigations as with irrigating at 1.0 and 0.8 pan evaporation coefficients subjecting sunflower plants to soil water deficit which resulted in decrease in ETa values. The decreases in Cu value comprised 10.24 and 19.82% in the first season and 15.31 and 25.79% in the second one as irrigation was practiced at 1.0 and 0.8 pan evaporation coefficients comparable with 1.2 one, respectively. These results are go parallel with those obtained by Kramer (1983) and El-Samanody .(2004).

2- Sunflower potential evapotranspiration estimated by some empirical ETa formulae:

The values in Table (8) show the values of potential evapotranspiration estimated by four formulae viz. Modified Penman, Penman Monteith, Doorenbos and pruitt and evaporation pan. Results pointed out that potential evapotranspiration started as low at the beginning of the growing season then gradually increased to reach its maximum value at mid-season (during August) and decreased again at the end of the season. Results also cleared that Penman Montieth formula gave the maximum seasonal potential evapotranspiration during the two growing seasons, while, evaporation pan formula gave lower value of potential evapotranspiration. Generally, the differences in potential evapotranspiration during the two seasons are mainly due to the weather factors used for each formula.

Table (8): ETo (mm / month and mm / season) for Modified Penman , Penman – Monteith , Doorenbos- Pruitt and Evaporation pan formulae and Actual ET for sunflower crop in 2003 & 2004 seasons.

Month	Modified Penman (mm / month)		Penman -Monteith (mm / month)		Doorenbos- Pruitt (mm / month)		Evaporation pan (mm / month)		Actual Eta (mm / month	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
June	16.77	16.91	20.08	24.08	17.53	17.89	21.67	17.61	14.7	11.63
July	172.33	172.00	194.73	215.28	163.37	158.89	177.60	160.74	164.50	153.62
August	184.73	177.94	194.99	241.18	174.53	177.94	178.87	151.90	208.91	200.60
September	76.18	72.86	80.21	101.66	72.14	73.73	65.81	59.04	49.09	43.15
Seasonal	450.01	439.71	490.01	582.2	427.57	428.45	443.95	389.29	437.20	409.00

3- Comparison with the actual evapotranspiration (ETa):

Results recorded in Table (9) demonstrated that evaporation pan method was superior for calculating crop evapotranspiration at Giza area, due to its least difference from the actual evapotranspiration value which ranged 2-5% in the two seasons of study as compared with Modified Penman, Penman-Montieth and Doorenbos and pruitt formulae.

Table (9) : Ratio of potential evapotranspiration (ETo) values calculated by different ET formulae to the actual ET of sunflower crop in 2003 & 2004 seasons

Formulae	2003 season		2004 season	
	ETo	Ratio	ETo	Ratio
Modified Penman	450.01	1.03	439.71	1.08
Penman Monteith	490.01	1.12	582.20	1.42
Doorenbos- Pruitt	427.57	0.98	428.45	1.05
Evaporation pan	443.90	1.02	389.29	0.95
Actual (ETa)	437.00	--	409.00	--

With respect to sowing dates, Eta values were 2055, 1637 and 1264 m^3/fed under early, intermediate and late sowing dates in season 2003, respectively. Whereas, the corresponding values in season 2004 were 1809, 1405 and 1238 m^3/fed, for the same respective sowing dates. These results indicate that delaying sowing date resulted in a reduction in ETa which are mainly due to the shorter growth season and lower both seed and biological yields. The reduction in Cu value, due to intermediate and late sowing dates, reached 20.34 and 38.49% in the first season and 22.33 and 31.56% in the second one, as compared with early sowing date, respectively. These results are in agreement with those obtained by Ali .(1998) and Samanody . (2004).

For nitrogen fertilizer treatments, as presented in Table (7) the results indicated that the values of actual water consumptive use were 1607 and 1697 m^3/fed under the recommended N dose and recommended N dose plus biofertilizer in season 2003, respectively, whereas, the corresponding values in season 2004 were 1447 and 1518 m^3/fed for the same respective treatments. These findings may be attributed to higher values of growth, yield and yield components of sunflower, under N fertilizer plus biofertilizer treatment, which reflected on higher Cu values.

4- Water use efficiency (W.U.E):

Water use efficiency (W.U.E), expressed in Kg seed./m^3 consumed water, for different irrigation regimes , sowing dates and nitrogen fertilizer treatments are tabulated in Table (7). It is obvious that the irrigation regimes

differentially affected WUE in the two seasons since irrigating at 1.2 pan evaporation coefficient resulted in higher WUE value in the first season while in the second one irrigating at 1.0 pan evaporation coefficient exerted the same effect. Data also revealed that higher WUE value was obtained under early sowing date, comparable with both intermediate and late ones. Applying N fertilizer plus biofertilizer improved WUE for sunflower crop more than N fertilizer alone. Maximum WUE value was resulted from irrigating at 1.2 pan evaporation coefficient as combined with early sowing date and recommended nitrogen dose plus bio-fertilizer in the first and second season., respectively.

On conclusion, it is advisable to sow sunflower early on June , applying the N fertilizer dose plus treating the seeds with biofertilizer (ceralen) and scheduling the irrigation at 1.2 pan evaporation coefficient in order to maximize water and crop productivity under Giza area conditions.

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تأثير بعض العوامل الزراعية على إنتاجيه و بعض العلاقات المائية لمحصول عباد الشمس

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الملخص العربي

أقيمت تجربتان حقليتان خلال موسمي ٢٠٠٤,٢٠٠٣ بمزرعة مركز البحوث الزراعية بالجيزة لدراسة اثر الري ومواعيد الزراعة و التسميد للنيتروجين على النمو والمحصول ومكوناته والعلاقات المائية لمحصول عباد الشمس صنف فيوديك و أوضحت نتائج الدر اسه الآتي:

- الاستهلاك المائي لمحصول عباد الشمس وصلت قيمته ١٦٥٢ ، ١٤٨٢ م^{3} / فدان خلال موسمي الدراسة على الترتيب و ذلك كمحصلة للمعاملات تحت الدراسة .
- كان افضل مستوى للري هو الري باستخدام معامل البخر ١.٢ حيث أعطى أعلى قيمه لصفات النمو وكذا المحصول ومكوناته خلال الموسمين .
- يمكن استخدام طريقه وعاء البخر القياسي بنجاح في حساب جهد البخر نتح النظري لمحصول عباد الشمس في منطقه الجيزه تليها معادلة **Doorenbos & Prutt**.
- تفوق ميعاد الزراعة في يونيه على المواعيد الأخرى في صفات النمو ، محصول الحبوب ومكوناته .
- تفوق استخدام التسميد المعدني + التسميد الحيوي على جميع صفات النمو والحبوب لمحصول عباد الشمس بالمقارنة بالمصدر المعدني فقط للنيتروجين. لذلك يمكن التوصية برى محصول عباد الشمس في منطقه الجيزه باستخدام بخر الوعاء القياسي مع استعمال معامل البخر ١.٢ والزراعة خلال النصف الثاني من يونيه مع استخدام التسميد المعدني + الحيوي كمصدر للنيتروجين