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WATER REQUIREMENTS OF CROPS UNDER NORTH SINAI CONDITIONS: 2- RESPONSE OF ARTICHOKE TO DEFICIT IRRIGATION AND ORGANIC APPLICATION AT EL–SHEIKH ZUWAYID REGION, EGYPT.

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This work is an attempt to clarify how much we can maximize the net return of using the limited water resources in agriculture. This can be achieved by combining the effect of organic additions and optimum water management systems in sandy soils to improve the water use efficiency and water economy of artichoke crop cultivated under desert conditions at El-Sheikh Zuwayid region, North Sinai, Egypt.

The study was conducted in split plot design in four replicates, the main treatment includes: three irrigation intervals using drip irrigation with emitters 4 l/hour ((I_1 = one day 2 times, 45 min (6 liter/plant) ; I_2 = two days 3 times, 45 min (9 liter/plant) and I_3 = three days 4 times, 45 min (12 liter/plant)) and sub main treatment include three levels of organic manure addition (OM_1= 19 , OM_2 = 24 and OM_3 = 28 m^3/fed and equal 6.30 , 7.88 and 9.45 ton/fed respectively). The results were analyzed statistically. From the experiment, the following results were obtained.

A highly significant increase in artichoke yield, water consumptive use, water use efficiency, water economy, crop coefficient and environmental stress coefficient by increasing organic manure level and increasing irrigation amount. Also, highly significant relations were obtained between irrigation intervals and levels of organic manure fertilization and their interactions. So, the highest value of artichoke yield, water consumptive use, water use efficiency, water economy, crop coefficient and environmental stress coefficient was obtained by applying irrigation water 2 times daily, 45 min (6 liter/plant) and by adding 9.45

ton feddan organic manure (OM_2 = 28 m^3/fed.). While the lowest values were obtained by applying irrigation water at interval I_3 = three days 4 times, 45 min (12 liter/plant) and by additional of organic manure OM_1=19 m^3/fed. The high response of artichoke to water irrigation considers a special case within the experimental boundaries.

Keywords: water requirements, irrigation intervals, organic manure, artichoke, water use efficiency, crop coefficient, environmental stress coefficient.

Desert soils suffer mainly from the shortage in water resources and rapid loosing of this limited source. Soil moisture management is one of the most critical problem facing soil and water conservation. It is essential to know the optimum time for irrigation, which can produce good yields. Dorn (1995) found that artichoke is one of the sensitive plants to severe heat, dry conditions and its moderate to salinity. Its nutritional needs are relatively high. So, the proper management of such conditions in order to getting high productivity is an important goal in the desert locations. Shaxson and Barber (2003) stated that soil moisture is often neglected, but improved soil moisture management is crucial for sustainable improvement of food production and water supply. In many parts of the subhumid and semiarid tropics, crop yields are declining on response to inputs such as fertilizers, and droughts and shortages of irrigation water are increasingly evident.

Kirda (2000) stated that yield reductions from disease & pests, harvesting & storage losses and arising from insufficient fertilization are much greater than reductions expected from deficit irrigation. On the other hand, deficit irrigation and apply less fertilizer, adopt flexible planting dates, and select shorter-season varieties, where properly practised, may increase crop quality. Moutonnet (2000) mentioned that the upper limit for yield is set by soil fertility, climatic conditions and management practices, yield reaches the maximum value as does evapotranspiration. Any significant decrease in soil water storage has an impact on water availability for a crop and, subsequently, on actual yield and actual evapotranspiration.

Several investigators concluded that water use efficiency and water economy increased with decreasing the amount of irrigation water; irrigation intervals and by adding organic matter (Allen *et al.*, 1998; Rizk, 2002; Seidhom *et al.*, 2002; El-Dosouky *et al.*, 2005).

Environmental stress (Ks), which resulted from soil water shortage, low soil fertility, or soil salinity, can cause some types of plants to accelerate their reproductive cycle. In these situations, the length of the growing season may be shortened, particularly the mid-season period. Stress during the development period may increase the length of that period. Therefore, the length of the mid-season and perhaps the lengths of the development and late seasons may need to be adjusted for environmentally stressed or damaged vegetation. Local research and observation one critical to identify the magnitudes and extent of these adjustments (Rana *et al.*, 1996; Allen *et al.*, 1998; Rizk, 2002).

The aim of this work is to study the effect of organic additions and water management in sandy soils to improve water use efficiency and water economy of artichoke crop under desert conditions.

MATERIALS AND METHODS

The current work was carried out in the Agricultural Experimental Station of the Desert Research Center at EL–Sheikh Zuwayid city, about 35 km east of El-Arish city, North Sinai Governorate during 2003/2004 season.

Meteorological station is located inside the experimental field site whose altitude is about 15 meter above sea level, at latitude 31°08` N and longitude 34°01` E. Meteorological data for the season were used to compute ETo using Penman – Monteith equation (Table 1) by using CROPWAT, software version 5.7 (Smith, 1992). In general, the northeastern part of Sinai Peninsula is dominated by the Mediterranean climate, which is characterized by hot dry summer and relatively cold winter.

Meteorological Data

Comparing the ETo values for the average of 8 years (to compute Ks), table (1), with those computed for growth season 2003/2004 (to compute Kc), it is clear that the former is lower than both the latter's. The location is surrounded by some sand dunes, which may cause some advective heating to the site of experimentation, so it could result slight increase in the ETo values.

The physical and chemical characteristics of the studied soil site are recorded in tables (2a and b). The relevant physical and chemical properties of the soil of the experimental site were determined according to Richards (1954). The soils are non-saline, non-alkali, soil texture is sandy and available moisture reach 7 % w/w.

The study was conducted in split plot design in which four replicates for each treatment were used. Three irrigation intervals as main plots: I_1=one day 2 times, 45 min (6 liter/plant) & I_2=two days 3 times, 45 min (9 liter/plant) & I_3=three days 4 times, 45 min (12 liter/plant) and three levels of chicken manure as sub-main plots: OM_1=19 m^3/fed (6.30 ton/fed) & OM_2=24 m^3/fed (7.88 ton/fed) & OM_3=28 m^3/fed (9.45 ton/fed) were added before planting, its analysis is shown in table (3).

TABLE (1). Meteorological data of El-Sheikh Zuwayid region, North Sinai during 2003/2004 and ETo average of 8 years (1996-2003).

Year 2003	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
Max temp °C	21.20	19.74	21.35	27.75	32.76	35.64	38.61	39.63	37.59	33.99	28.35	21.74	29.86
Min temp °C	7.07	6.58	7.12	9.25	10.92	11.88	12.87	13.21	12.53	11.33	9.45	7.25	9.95
Avg temp °C	14.13	13.16	14.23	18.50	21.84	23.76	25.74	26.42	25.06	22.66	18.90	14.49	19.91
Max relative humidity (%)	82.43	73.51	81.41	78.07	87.59	92.28	91.33	92.42	83.75	89.80	87.31	81.64	85.13
Min relative humidity (%)	47.09	43.70	46.31	37.26	36.49	35.59	32.56	32.08	30.67	36.19	40.99	45.95	38.74
Wind speed (km/day)	259.20	245.52	164.40	177.60	141.36	76.08	176.40	76.32	163.92	297.84	201.60	274.56	187.90
Actual sunshine hours (n)	6.80	7.60	8.20	9.30	10.20	11.60	11.70	11.40	10.30	9.30	7.70	6.60	9.23
Rain (mm / month)	37.08	15.48	41.15	13.21	0.00	0.00	0.00	0.00	1.02	0.25	2.29	23.62	134.10*
ETo (mm/day)	2.35	2.85	3.06	4.51	5.29	5.62	6.79	5.73	5.69	5.10	3.09	2.48	4.38
Year 2004	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Avg
Max temp °C	19.65	20.06	24.89	26.99	30.95	34.82	38.66	39.09	37.53	34.70	28.40	19.79	29.62
Min temp °C	6.55	6.69	8.30	9.00	10.32	11.61	12.89	13.03	12.51	11.57	9.47	6.60	9.87
Avg temp °C	13.10	13.37	16.59	17.99	20.63	23.21	25.77	26.06	25.02	23.13	18.93	13.19	19.75
Max relative humidity (%)	79.55	88.63	81.52	85.23	85.55	92.99	94.61	91.99	88.51	95.23	90.16	88.49	88.54
Min relative humidity (%)	47.41	52.24	42.08	41.54	37.43	36.66	33.69	32.38	32.47	37.67	42.28	52.55	40.70
Wind speed (km/day)	237.60	281.52	235.44	205.68	169.68	79.68	105.36	114.96	59.04	234.72	310.08	125.52	179.94
Actual sunshine hours (n)	7.06	7.74	8.28	9.38	10.41	11.90	11.96	11.25	10.30	9.08	7.69	6.71	9.31
Rain (mm / month)	33.02	29.21	19.05	0.25	0.50	0.00	0.00	0.00	0.00	0.76	75.94	99.31	258.04*
ETo (mm/day)	2.21	2.46	3.69	4.44	5.28	5.59	6.21	6.02	4.59	4.63	3.52	1.69	4.19
ETo of 8 years (mm/day)	2.15	2.65	3.19	4.43	5.18	5.70	6.11	5.77	5.20	4.12	3.12	2.39	4.17

* Total

ETo = Potential evapotranspiration (mm/day)

TABLE (2a). Some physical properties of the soils selected for experimental work.

Soil depth (cm)	Particle size distribution (%)				Texture class	Particle density (g/cm^3)	Bulk density (g/cm^3)	Total porosity (%)	Organic matter (%)	Moisture content (%)		Available soil water/layer		Infiltration rate	
	Coarse sand	Fine sand	Silt	Clay						Field capacity	Wilting point	(%)	(mm)	(cm/hr)	Class
0-30	7.57	87.55	2.47	2.41	Sandy	2.52	1.46	42.11	0.26	9.89	2.79	7.10	103.7	16.4	Very rapid
30-60	7.25	87.81	2.69	2.25	Sandy	2.55	1.45	43.32	0.24	10.12	2.87	7.25	104.8		
60-90	8.02	86.28	2.55	3.14	Sandy	2.54	1.43	43.89	0.29	8.44	2.59	5.85	83.4		
90-120	7.75	86.61	2.29	3.34	Sandy	2.60	1.50	42.31	0.27	8.46	2.64	5.82	87.3		

TABLE (2b). Some chemical and physico-chemical properties of the soils selected for experimental work.

Soil depth (cm)	$CaCO_3$ (%)	pH soil paste	ECe (dSm^{-1})	Soluble cations (me/l)				Soluble anions (me/l)				CEC (me/100g soil)	Exchangeable cations (me/100g soil)			
				Ca^{++}	Mg^{++}	Na^+	K^+	$CO_3^{=}$	HCO_3^-	$SO_4^{=}$	Cl^-		Ca	Mg	Na	K
0-30	4.87	7.88	1.63	8.02	1.19	1.50	5.58		4.19	7.53	4.59	4.62	3.28	0.30	0.83	0.21
30-60	4.94	7.91	1.69	8.27	1.32	1.57	5.71		4.46	7.48	4.88	4.67	3.44	0.35	0.64	0.24
60-90	5.33	7.85	1.72	8.31	1.39	1.64	5.85		4.86	6.09	6.23	4.71	3.48	0.36	0.67	0.20
90-120	5.41	7.97	1.73	8.47	1.50	1.57	5.80		4.64	6.18	6.52	4.79	3.54	0.34	0.73	0.18

TABLE (3). Some chemical properties of chicken manure applied to soil selected for experimental work.

Sample	pH	E.C. (dS/m)	OM (%)	C (%)	N (%)	C/N (%)
1	7.72	1.84	52.28	29.33	2.21	13.27
2	7.94	1.88	54.44	33.15	2.27	14.60

OM = Organic matter C = Carbon N = Nitrogen

Seeds of artichoke were sown in lines on July 15th 2003. Drip irrigation system having 4 liter / hour GR dripper was used. The distance between the lateral lines was one meter and drippers were located at one meter apart. Consequently, the number of plants per feddan reaches 4000 plants.

Artichokes require less fertilizer NPK than most other vegetable crops to produce top yields. In drip-irrigated fields, 25 kg/fed of N and half of the P_2O_5 and K_2O were banded in two bands 5–10 cm apart and about 15 cm below the transplant line. The remaining fertilizer was applied in equal weekly applications throughout the season. At the end of the growth season artichoke yield was harvested on March 15th 2004. Ground water was used for irrigation. Its salinity was 3100 ppm, table (4).

TABLE (4). Chemical analysis of the irrigation water of north Sinai research station.

Season	pH	E.C.		S.A.R.	R.S.C. (me/l)	T.D.S. (ppm)	Units	Soluble cations				Total	Soluble anions				Total	Class
		ppm	dSm^{-1}					Ca^{++}	Mg^{++}	Na^{+}	K^{+}		$CO_3^{=}$	HCO_3^{-}	$SO_4^{=}$	Cl^{-}		
Winter	7.8	3099	4.84	16.55	-4.82	2920	ppm	88.88	76.08	880.0	12.0	1057.0	0.00	358.2	625	1059	1863	C_3S_1
							epm	4.44	6.26	38.26	0.31	49.26	0.00	5.87	13.01	29.86	48.74	
							%	9.00	12.71	77.67	0.62	100.0	0.00	12.05	26.70	61.26	100.0	
Summer	7.6	3236	5.06	9.45	-18.92	3161	ppm	215.7	128.64	710.0	8.00	1062.3	0.00	148.23	725	1300	2099	C_3S_1
							epm	10.76	10.58	30.87	0.20	52.42	0.00	2.43	15.09	36.66	54.19	
							%	20.53	20.19	58.89	0.39	100.0	0.00	4.48	27.86	67.66	100.0	

S.A.R = Sodium adsorption ratio. R.S.C. = Residual sodium carbon. T.D.S. = Total dissolved solids. epm.= equivalent per million

TABLE (5). Amounts of irrigation water applied to artichoke plants during the season 2003/2004.

Irrigation Intervals, days	Initial m^3/fed /day	m^3/fed /season	mm/fed /season	mm / day
One day, 2 times 45 min (6 liter/plant)	24	5935.53	1413.22	6.14
Two days, 3 times 45 min (9 liter/plant)	18	4555.53	1084.65	4.72
Three days, 4 times 45 min (12 liter/plant)	16	4095.53	975.126	4.24

The amounts of applied irrigation water during irrigation period (230 days) are shown in table (5) include rainfall all over the season of 244 days (415.53 m^3/fed). To determine the actual water consumption soil moisture tension was measured by tensiometer, while moisture content was determined by gravimetric method and hence the actual evapotranspiration was calculated by the following equation of Doorenbos and Pruitt (1977):

$$ETa = (M.2\ \% - M._1\ \%) \times d_b \times D \times 1000\ mm$$

Where:

ETa = actual evapotranspiration (mm).
$M._2$ = Moisture content after irrigation (%).
$M._1$ = Moisture content before irrigation (%).
d_b = Bulk density of soil (g / cm^3)
D = Active root depth (m).

Water use efficiency was calculated by dividing the crop yield by the amount of seasonal evapotranspiration according to Giriappa, (1983). Water economy was calculated by dividing the crop yield by the amount of water added as kg/m^3 according to Talha *et al.* (1980). Crop coefficient was calculated by dividing the actual evapotranspiration (ETa) by potential evapotranspiration (ETo) according to Yaron *et al.* (1973). Environmental stress coefficient (Ks) was calculated by dividing the actual evapotranspiration (ETa) by maximum crop evapotranspiration (ETc) according to Allen *et al.* (1998). At the end of the experiment, artichoke yield was harvested and recorded. Data were subjected to the analysis of variance according to Snedecor and Cochran (1989). Investment Ratio (IR) = Output LE / Input LE according to Rana *et al.* (1996).

RESULTS AND DISCUSSION

Artichoke Yield

Data presented in table (6) show that highly positive significant response in artichoke yield, with either amount or irrigation water or organic manure level.

Quantitvely, the multiple regression equation that correlates the yield (kg/fed), as (y) with both amount of irrigation water (m^3/fed), as (x_1) and organic manure amount (kg/fed), as (x_2) is as follow;

$Y = 1.48\,x_1 + 1.11\,x_2 - 9297.2.$ $R^2 = 0.944$ **

This relation means that each added 1 m^3/fed of irrigation water and adding 1 kg/fed of chicken manure will add 1.48 and about 1.11 kg/fed for the artichoke yield, respectively. This finding due to the increase in NPK uptake by adding organic manure which, changes the rhizosphere toward more water utilization of plants. These results are in agreement with Dorn (1995); Moutonnet (2000) and Shaxson and Barber (2003).

TABLE (6). Artichoke yield grown at El-Sheikh Zuwayid region.

Irrigation intervals, days	Organic manure, ton/fed	Number of head/fed	kg/fed
One day, 2 times 45 min (6 liter/plant)	OM1=6.3	32177.25 c	5362.88
	OM2=7.88	51817.50 b	8636.25
	OM3=9.45	62921.25 a	10486.88
Average		48972.00	8162.00 a
Two days, 3 times 45 min (9 liter/plant)	OM1=6.3	27877.50 c	4646.25
	OM2=7.88	42525.00 b	7087.50
	OM3=9.45	47486.25 a	7914.38
Average		39296.25	6549.38 b
Three days, 4 times 45 min (12 liter/plant)	OM1=6.3	25263.00 c	4210.50
	OM2=7.88	31578.75 b	5263.13
	OM3=9.45	37800.00 a	6300.00
Average		31547.25	5257.88 c
L.S.D. 0.05	Intervals	***	325.17
	O.M	***	178.74
	Interactions between Intervals and O.M	***	325.65

a. b. c. letters indicated to significant differences between treatments.

Actual Evapotranspiration (ETa)

Actual evapotranspiration is the combination of two processes, evaporation from soil and plant surfaces and transpiration from plant. Likewise, highly positive significant response in water consumptive use with either irrigation water amount or organic manure level (Table 7).

In order to detect the water saving amount which resulted from water applications to artichoke crop, the actual effective irrigation water amount as a percent from the total added water referring to irrigation efficiency value was calculated (Table 7) and compared with that estimated by actual ET values. The last column (Table 7), indicate that more than 99 % of effective water has been consumed actually by applying the experiment as minimum level, while reached to > 100 % as maximum one.

TABLE (7). Monthly, seasonally actual evapotranspiration and water saving of artichoke grown at El-Sheikh Zuwayid region.

Irrigation intervals, days	O.M. levels	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Liter/plant/day	Liter/plant/season	mm/day	mm/season	m^3/fed/season	Modified ETa m^3/fed/season	P.I. m^3/fed/season	W.S.L. m^3/fed/season	W.S.L. %
One day	OM1	2.92	4.09	5.38	5.09	3.15	2.53	2.15	2.23	2.48	3.34	834.00	3.18	791.3	3336.0	3924.72	5520.00	-1595.3	-28.9
	OM2	3.42	4.39	5.74	5.20	3.18	2.58	2.20	2.41	2.52	3.51	875.25	3.35	833.6	3500.9	4118.81	5520.00	-1401.2	-25.4
	OM3	3.56	4.51	5.98	5.36	3.24	2.61	2.22	2.43	2.36	3.59	895.31	3.42	852.7	3581.2	4213.22	5520.00	-1306.8	-23.7
Average		3.30	4.33	5.70	5.22	3.19	2.57	2.19	2.35	2.45	3.48	868.19	3.31	826.8	3472.8	4085.58	5520.00	-1434.4	-26.0
Two days	OM1	2.71	4.03	5.08	4.88	3.02	2.45	2.11	2.15	2.32	3.19	800.78	3.04	762.7	3203.1	3768.37	4140.00	-371.6	-9.0
	OM2	3.14	4.21	5.56	5.20	3.15	2.48	2.15	2.33	2.29	3.39	848.33	3.23	807.9	3393.3	3992.16	4140.00	-147.8	-3.6
	OM3	3.28	4.27	5.68	5.14	3.15	2.58	2.18	2.38	2.56	3.17	863.92	3.30	822.8	3455.7	4065.52	4140.00	-74.5	-1.8
Average		3.04	4.17	5.44	5.07	3.10	2.50	2.15	2.29	2.39	3.35	837.68	3.19	797.8	3350.7	3942.02	4140.00	-197.9	-4.8
Three days	OM1	2.57	3.91	4.96	4.82	2.95	2.40	2.01	2.10	2.40	3.13	783.47	2.98	746.2	3133.9	3686.90	3680.00	6.90	0.2
	OM2	2.85	4.03	5.20	4.98	3.08	2.48	2.13	2.20	2.25	3.24	813.78	3.09	775.0	3255.1	3829.54	3680.00	149.54	4.1
	OM3	2.99	4.09	5.44	5.09	3.11	2.53	2.18	2.28	2.44	3.35	837.60	3.19	797.7	3350.4	3941.65	3680.00	261.65	7.1
Average		2.80	4.01	5.20	4.97	3.05	2.47	2.11	2.19	2.36	3.24	811.62	3.09	773.0	3246.5	3819.37	3680.00	139.37	3.8
L.S.D. 0.05	Irrigation intervals												0.05		***				
	O.M. levels												0.05		***				
	Interactions between Intervals and O.M.												0.03		***				

Modified ETa = ETa / system efficiency. & P.I. = Proposed irrigation water amount = Planned irrigation – Rainfall & W.S.L.= Water saving or loss = Modified ETa - Proposed irrigation amount.

O.M. = Organic manure

These findings may be due to increasing evapotranspiration by adding organic manure, which could be contributed to providing sufficient amount of available soil moisture to roots. Similar results were obtained by Kirda (2000); Moutonnet (2000) and Shaxson and Barber (2003).

Water Use Efficiency of Artichoke (W.U.E.)

Table (8) indicates the values of water use efficiency as kg/m^3, which indicate highly positive relations between WUE values in one side and both amount of irrigation water and organic manure in the other side. However quantitatively, the multiple linear relation regression equation that correlates the WUE values (kg/m^3), as (y) with both amount of irrigation water (m^3/fed), as (x_1) and organic manure amount (kg/fed), as (x_2) is as follow:

$$Y = 0.0003\,x_1 + 0.0003\,x_2 - 2.077. \qquad R^2 = 0.941^{**}$$

TABLE (8). Water use efficiency and water economy (kg/m^3) of artichoke grown at El-Sheikh Zuwayid region.

Irrigation Intervals, days	Organic manure, ton/fed	Water use efficiency (kg/m^3)	Water economy (kg/m^3)	Modified water economy (kg/m^3)
One day, 2 times 45 min (6 liter/plant)	OM1=6.3	1.61	0.90	1.37
	OM2=7.88	2.47	1.46	2.10
	OM3=9.45	2.93	1.77	2.49
Average		2.35	1.38	2.00
Two days, 3 times 45 min (9 liter/plant)	OM1=6.3	1.45	1.02	1.23
	OM2=7.88	2.09	1.56	1.78
	OM3=9.45	2.29	1.74	1.95
Average		1.95	1.44	1.66
Three days, 4 times 45 min (12 liter/plant)	OM1=6.3	1.34	1.03	1.14
	OM2=7.88	1.62	1.29	1.37
	OM3=9.45	1.88	1.54	1.60
Average		1.62	1.28	1.38

It seems, generally, that artichoke plants could benefit well from the engaged additions of available moisture and organic manure in producing more tops on the plants. The presence of sufficient moisture around roots could facilitate both organic matter decaying and releasing nutrients in available form to the plant. In turn, the occurrence of O.M. reserves water to supply root extraction, so enhancing growth. So, it is suggest that these conditions activate both water and nutrient consumptions by roots of artichoke plants, which affect the crop yield. Similar results were obtained by Rizk (2002), Seidhom *et al.* (2002) and El-Dosouky *et al.* (2005).

Water Economy of Artichoke (W. Eco.)

Water economy calculated for the efficiency of the added irrigation water in producing the crop yield. So, as the experiment shows that the applied irrigation water should be modified upon ETa values, therefore table (8) contains two columns for water economy, one for the applied amount whiles the other for the modified amount.

Likewise, data presented in Table (8) reveal that the same trend of water use efficiency of artichoke was observed for water economy which, increased by shortening irrigation interval and by increasing organic manure level, (Table, 8). The highest water economy of artichoke was associated with daily irrigation, 2 times, 45 min (6 liter/plant) and adding organic manure at a rate of OM_3 = 28 m^3/fed.

These findings may be due to amount of stored soil moisture and also to activate both water and nutrient consumptions by artichoke roots, which gave high yields, thereby high water economy values. Similar results were obtained by Allen *et al.* (1998), Rizk (2002), Seidhom *et al.* (2002) and El-Dosouky *et al.* (2005).

Crop Coefficient (Kc) of Artichoke

One of the most important targets for establishing water requirement experiments is to adjust the local crop coefficient used in calculating the consumptive use of certain crops. So, the crop coefficient is useful in meeting the irrigation needs of crops and in efficient utilization of the scarcely available and costly water in arid areas. It is also used in computerized irrigation programs.

TABLE (9). Crop coefficient (Kc) of artichoke grown at El-Sheikh Zuwayid region.

Irrigation Intervals, days	Organic manure, ton/fed	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Season Kc
One day, 2 times 45 min (6 liter/plant)	OM1=6.3	0.41	0.68	0.90	0.95	0.97	0.97	0.93	0.86	0.61	0.81
	OM2=7.88	0.48	0.73	0.96	0.97	0.98	0.99	0.95	0.93	0.65	0.85
	OM3=9.45	0.50	0.75	1.00	1.00	1.00	1.00	0.96	0.94	0.66	0.87
Average		0.46	0.72	0.95	0.97	0.98	0.99	0.95	0.91	0.64	0.84
Two days, 3 times 45 min (9 liter/plant)	OM1=6.3	0.38	0.67	0.85	0.91	0.93	0.94	0.91	0.83	0.59	0.78
	OM2=7.88	0.44	0.70	0.93	0.97	0.97	0.95	0.93	0.90	0.63	0.82
	OM3=9.45	0.46	0.71	0.95	0.96	0.97	0.99	0.94	0.92	0.64	0.84
Average		0.43	0.69	0.91	0.95	0.96	0.96	0.93	0.88	0.62	0.81
Three days, 4 times 45 min (12liter/plant)	OM1=6.3	0.36	0.65	0.83	0.90	0.91	0.92	0.88	0.81	0.58	0.76
	OM2=7.88	0.40	0.67	0.87	0.93	0.95	0.95	0.92	0.85	0.60	0.79
	OM3=9.45	0.42	0.68	0.91	0.95	0.96	0.97	0.94	0.88	0.62	0.81
Average		0.39	0.67	0.87	0.93	0.94	0.95	0.91	0.85	0.60	0.79

Generally, similar trend to the aforementioned parameters are observed for crop coefficient of artichoke (Table 9). A highly significant positive relation for crop coefficient with both irrigation water and organic manure levels. As a general trend the values increase gradually from July up to November and December as maximum than declined up to maturity in February. Similar results were obtained by Doorenbos and Pruitt (1977) and Allen *et al.* (1998).

Environmental Stress Coefficient (Ks)

This parameter deals with how far could the actual evapotranspiration values represent the crop ones, so for soil water limiting conditions Ks will be < 1, while with no soil water stress Ks = 1.

Table (10) indicates the Ks values being < 1 for drier treatments of three and two days (i.e. treatments I_3 and I_2) especially with OM_1 and OM_2 levels, while more close to unity for one day treatment especially with OM_3, increased by shortening irrigation interval and by increasing organic manure level, with highly significant effect and differences (Table 10).

TABLE (10). Environmental stress coefficient of artichoke grown at El-Sheikh Zuwayid region.

Irrigation Intervals, days	Organic manure, ton/fed	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Ks Season
One day, 2 times 45 min (6 liter/plant)	OM1=6.3	0.96	0.89	0.99	1.08	0.92	1.01	1.00	0.89	1.11	0.98
	OM2=7.88	1.12	0.95	1.05	1.10	0.93	1.03	1.02	0.96	1.13	1.03
	OM3=9.45	1.17	0.98	1.10	1.13	0.95	1.04	1.03	0.97	1.06	1.05
Average		1.08	0.94	1.04	1.10	0.93	1.03	1.02	0.94	1.10	1.02
Two days, 3 times 45 min (9 liter/plant)	OM1=6.3	0.89	0.87	0.93	1.03	0.88	0.98	0.98	0.85	1.04	0.94
	OM2=7.88	1.03	0.91	1.02	1.10	0.92	0.99	1.00	0.93	1.02	0.99
	OM3=9.45	1.07	0.92	1.04	1.09	0.92	1.03	1.01	0.95	1.15	1.02
Average		1.00	0.90	1.00	1.07	0.91	1.00	1.00	0.91	1.07	0.98
Three days, 4 times 45 min (12 liter/plant)	OM1=6.3	0.84	0.85	0.91	1.02	0.86	0.96	0.95	0.83	1.08	0.92
	OM2=7.88	0.93	0.87	0.95	1.05	0.90	0.99	0.99	0.87	1.01	0.95
	OM3=9.45	0.98	0.89	1.00	1.08	0.91	1.01	1.01	0.91	1.09	0.99
Average		0.92	0.87	0.95	1.05	0.89	0.98	0.98	0.87	1.06	0.95

This may be interpreted by the effect of increasing actual evapotranspiration and crop coefficient (Kc) on increasing (Ks) as well. This could be considered as water saving parameter and suitable environmental conditions. Similar findings were reported by Rana *et al.* (1996), Allen *et al.* (1998) and Rizk (2002).

Economical Assessment

The values of investment ratio (IR) are illustrated in table (11). The IR values indicate that the cultivation of artichoke in similar locations to El-Sheikh Zuwayid region is profitable to farmers under any case of application. However, as consider to the shortage of water resource in this area the maximization of profit is an important goal.

The economical evaluation of the experimental findings in any research is of a great importance depending on the net return of such treatments, which could encourage the farmer to apply. So, it is clear that using the combination of the traditional quantities of organic manure (28 m^3/fed) and daily irrigation, 2 times, 45 min (6 liter/plant) give the best values of IR of artichoke plants (4.11 LE/1LE). Moreover, this treatment characterized by the quite adjustment of water applied with that have to be added upon climatological data, table (11). Also, using moderate and high O.M. doses contribute with the highest IR values.

TABLE (11). Input and output items of artichoke yield grown in El-Sheikh Zuwayid region.

Items	Irrigation intervals, days	One day, 2 times 45 min (6 liter/plant)			Two days, 3 times 45 m (9 liter/plant)			Three days, 4 times 45 min (12 liter/plant)		
	Organic manure levels	OM_1=6.30	OM_2=7.88	OM_3=9.45	OM_1=6.30	OM_2=7.88	OM_3=9.45	OM_1=6.30	OM_2=7.88	OM_3=9.45
List of inputs	Soil moving, LE/fed	300	300	300	300	300	300	300	300	300
	Land preparation, LE/fed	60	60	60	60	60	60	60	60	60
	Seeds, LE/fed	200	200	200	200	200	200	200	200	200
	Cultivation, LE/fed	60	60	60	60	60	60	60	60	60
	Irrigation, LE/fed	1483.9	1483.9	1483.9	1138.9	1138.9	1138.9	1024	1024	1024
	Modified irrigation, LE/fed	981.2	1029.7	1053.3	942.1	998.0	1016.4	921.7	957.4	985.4
	Organic fertilization, LE/fed	1300	1600	1900	1300	1600	1900	1300	1600	1900
	Mineral fertilization, LE/fed	200	200	200	200	200	200	200	200	200
	Weed control, LE/fed	60	60	60	60	60	60	60	60	60
	Pest control, LE/fed	60	60	60	60	60	60	60	60	60
	Labors costs, LE/fed	60	60	60	60	60	60	60	60	60
	Machines, LE/fed	60	60	60	60	60	60	60	60	60
	Fuel, LE/fed	100	100	100	100	100	100	100	100	100
	Harvesting, LE/fed	100	100	100	100	100	100	100	100	100
	Crop transportation, LE/fed	60	60	60	60	60	60	60	60	60
	Rent (on season), LE/fed	400	400	400	400	400	400	400	400	400
	Total input, LE/fed	4503.9	4803.9	5103.9	4158.9	4458.9	4758.9	4043.9	4343.9	4643.9
	Modified total input, LE/fed	4001.2	4349.7	4673.3	3962.1	4318.0	4636.4	3941.7	4277.4	4605.4
List of outputs	Yield, kg/fed	5362.88	8636.25	10486.88	4646.25	7087.50	7914.38	4210.50	5263.13	6300.00
	Price, LE/kg	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Total price, LE/fed	10726	17273	20974	9293	14175	15829	8421	10526	12600
	Net income, LE/fed	6222	12469	15870	5134	9716	11070	4377	6182	7956
	Modified net income, LE/fed	6724.6	12922.8	16300.5	5330.4	9857.0	11192.4	4479.3	6248.9	7994.6
Investment ratio (IR)		2.38	3.60	4.11	2.23	3.18	3.33	2.08	2.42	2.71
Modified investment ratio (IR)		2.68	3.97	4.49	2.35	3.28	3.41	2.14	2.46	2.74

* Modified irrigation = irrigation / system efficiency

CONCLUSION

It is suggested that renewing of organic addition should be annually for sandy soil, and daily irrigation with drip irrigation emitter 4 l/hour 2 times, 45 min (6 liter/plant) gave the highest water use efficiency of artichoke. This, may be, a special case for this kind of crops, which produce more yield for the added irrigation water within the boundaries of the experiment.

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الاحتياجات المائية للمحاصيل تحت ظروف شمال سيناء:
٢- استجابة الخرشوف لنقص الري والإضافة العضوية في منطقة الشيخ زويد – مصر.

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يهدف هذا البحث إلى دراسة تأثير إدارة مياه الري وإدارة فترات الري مع إضافة السماد العضوي لنباتات الخرشوف تحت ظروف الري بالتنقيط في الأراضي الرملية الصحراوية بمحافظة شمال سيناء على كفاءة استخدام المحصول للمياه واقتصاديات المياه. أقيمت التجربة بمزرعة محطة بحوث الشيخ زويد بشمال سيناء وتضمنت التجارب ثلاث فترات ري (كل يوم ساعة ونصف على مرتين، كل يومين ساعتين وربع على ثلاث مرات، كل ثلاث أيام ثلاث ساعات على أربع مرات) بكميات مياه ري مختلفة وثلاث مستويات سماد عضوى (١٩ ، ٢٤ ، ٢٨م^{٣} / فدان تعادل ٦,٣٠ ، ٧,٨٨ ، ٩,٤٥ طن/فدان على الترتيب) ولأربع مكررات خلال موسم٢٠٠٣/٢٠٠٤.

وقد تم تحليل النتائج إحصائيا وأوضحت النتائج زيادة معنوية لعدد النورات ومحصول الخرشوف فى الفدان ، والاستهلاك المائى وكفاءة استخدام المحصول للمياه واقتصاديات مياه الري ومعامل المحصول ومعامل الإجهاد البيني ومعدل الاستثمار (عائد الجنيه) بنقص فترة وكمية الري ، وبزيادة مستوى التسميد العضوي. وكانت هناك فروق معنوية بين فترات الري وكمية مياه الري المختلفة، وأيضا بين مستويات التسميد المختلفة، وبين التفاعل بين فترات الري ومستويات التسميد.

ولوحظ أنه يزيد المحصول وترشيد مياه الري بزيادة إضافة السماد العضوي سنويا للأراضي الرملية وبالرى يوميا. وأوصت الدراسة بالرى بالتنقيط (نقاط ٤ لتر/ساعة) يوميا ساعة ونصف على مرتين (٤٥ دقيقة) بكمية مياه رى ٦ لتر لكل نبات يوميا، وإضافة المادة العضوية كل عام إلى التربة الرملية بمعدل ٢٨ م^{٣} / فدان (٩,٤٥ طن/فدان) تحت الظروف المشابهة لمنطقة الدراسة. هذه الحزمة من التقنيات أعطت أعلى كفاءة لاستخدام المحصول للمياه وأعلى عائد للجنيه للفدان بلغ حوالي ٤,١١ جنيه لكل جنيه مستثمر وتعتبر هذه حالة متميزة لهذا المحصول.