Prediction of Traditional Climatic Changes Effect on Pomegranate Trees under Desert Conditions in El-maghara, Egypt

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Abstract: The main aim of this study is to combat and forecasting climate changes, with some soil managements in El-Maghara Research Station at North Sinai, Egypt, on pomegranate trees. The applied treatments were irrigation intervals and soil mulching with drip irrigation in desert sandy soils and its impact on the water use efficiency and saving of irrigation water. A field experiment was carried out through split plot design during the three seasons 2008, 2009 and 2010 with pomegranate trees have 9 years age, planted at distances 3.6 X 3.6 meters (324 tree/fed). Experiments included 72 test unit consists of three irrigation intervals (2, 4 and 6 days) and three soil mulching practices under the trees (control without mulch, bitumen mulch and olive pomace mulch) and four replicates each have two trees, as the amount of irrigation water was calculated according to Penman - Monteith equation for data the last 10 years of the meteorological data of the region. The results were analyzed statistically which were as follow: (1) There is a detected local climatic change for the main meteorological data of the site compared either with 10 or 30 years recorded data. These changes are partially caused by the global climatic change in one hand and to the local Oasis effect in the site in the other hand. These changes play a positive role in enhancing the yield of pomegranate trees referring to the horticulture references. (2) A significant increase of the values of pomegranate fruit yield, crop water use efficiency, water economy, water saving, total revenue and total profit by increasing of air temperature and humidity of the atmosphere and increasing the irrigation period to 6 days. Olive pomace mulch under the trees, gave higher yield than bitumen mulch, and without mulch. (3) A significant decrease values of water consumptive use, crop coefficient of pomegranate, irrigation water use efficiency coefficient and environmental stress coefficient by increasing the irrigation period to be 6 days. Olive pomace mulching under the trees gave higher yield than bitumen mulch and then without mulch. (4) The highest for the application of economic olive pomace mulch under irrigation with a period of 6 days. In all cases, the applied treatments get higher investment ratios (IR) than the traditional one (2.25 LE/IL). The study recommends with using drip irrigation every 6 days by the amount of irrigation water calculated according to Penman-Monteith equation without addition leaching requirements, with plants residues mulch such as olive pomace under the trees, which gave the highest return of one pound investment with ~ 3.07 LE., taking into account the vulnerability of the study area to the phenomenon of the Continental and Oasis effect, under conditions similar to the study area.

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1. Introduction:

Climatic change is nowadays one of the highly negotiable issues which are not likely to be achieved soon (IPCC, 2007). Mark and Piet Rietveld (2009) stated that the climate change is almost invariably considered an issue of global interest, and therefore also judgments about mitigation and adaptation costs to be made now, differ widely. Supit *et al.*, (2010) stated that the recent changes in the simulated potential crop yield and biomass production caused by changes in the temperature and global radiation patterns are examined, using the Crop Growth Monitoring System. Peter *et al.*, (2005) stated that the oasis self-supporting mechanisms due to oasis breeze circulation are proposed and simulated numerically. Excessive evaporation from the oasis makes the oasis surface colder than the surrounding desert surface.

Pomegranate trees (*Punica granatum. L*) are widely grown in the warmest area of the Mediterranean basin and Southern Asia. This tree species is well adapted to arid soils, where long periods of soil water deficit are usually present during the dry season. For sustainable water use agriculture, crop-specific and water-saving irrigation techniques that do not negatively affect crop productivity must be developed. Worldwide, successful attempts have been documented regarding the use of water regimes and mulching techniques to improve water use efficiency in various tree crop species. Thus conserving water is an important aspect for agricultural expansion particularly in arid and semiarid regions where water deficit and high temperature are the main limiting factors for plant growth and productivity. Sheets *et al.*, (2008) reported that the pomegranates are native to grown in ancient Egypt and can be grown in tropical to warm temperate climates. Bakeer (2009) concluded that anti-transpirants of kaolin at 6 % with olive pomace mulching within trees by the regulated deficit irrigation 75 % of crop evapotranspiration showed an increase in water use efficiency to improve vegetative growth, leaf nutrient content, blooming & fruiting, fruit set and yield. While it decrease fruit split, and fruit physical and chemical properties as well as economic revenue of pomegranate trees grown in El-Maghara, Egypt.

Allen *et al*. (1998) stated that mulches are effective in reducing ET of crop and crop coefficient values decrease by an average of 10 – 30 % due to the 50 – 80 % reduction in soil evaporation, but crop growth rates and yield were increased by the use of mulches. Seidhom and Evon (2006) found that a significant increase of fruit yield, water consumptive use, irrigation water use efficiency coefficient, crop coefficient, environmental stress coefficient, water use efficiency, water economy and investment ratio by using black plastic mulch under olive trees followed by gravel mulch, with wider irrigation interval of 6 days, at El-Maghara, Egypt.

Lawand and Patil (1994) and Chopade *et al.,* (2001) observed that the pomegranate fruit yield/tree was greatest at an irrigation water (IW)/cumulative pan evaporation (CPE) of 0.8 with a constant depth of 50 mm. Abou-Aziz *et al.*, (1995) and Afria *et al.*, (1998) recorded that when soil reached 60 or 40% of field capacity, irrigation regime resulted in the highest pomegranate fruit numbers and yields (36.8 and 69.2 kg/tree, respectively, averaged over both years). Prasad *et al.*, (2003) stated that drip irrigation at 8 liters h^{-1} day^{-1} for 3 h increased the pomegranate yield from 17.7 kg $plant^{-1}$ under the control to 28.2 kg $plant^{-1}$. Narendra and Shallendra (2007) reported that the highest yield of pomegranate is (48.46 kg/tree). Shallendra and Narendra (2005) found that 8 liters of water per hour through trickle irrigation gave the highest number of fruits per plant, fruit weight, fruit length, fruit diameter, total soluble solids content, sugar content, pomegranate yield and water use efficiency and the lowest acidity.

Farshi, (2001) found that irrigation water use efficiency (IWUE) in drip irrigation was better than for surface irrigation and WUE of pomegranate increased from 2.1 kg/m^3 for surface irrigation, to 9.2 kg/m^3 for drip irrigation. Irrigation water savings of 58% were achieved for drip irrigation. Singandhupe *et al.*, (2003) concluded that irrigation at 100% pan evaporation resulted in 18.1% higher pomegranate fruit yield. El-Kassas, *et al.*, *(*1992) and Gupta *et al.*, (1999) observed that mulching produced the highest pomegranate fruit yields (72.6, 71.9 and 68.2 kg/tree, respectively). Singh *et al.*, (2003) found that mulching reduced fruit cracking of pomegranate, with dried grass or farmyard manure being the most effective and increasing yield. Hasan *et al.*, (2002) stated that the total water consumption and water use efficiency were highest under the highest soil moisture regime with black polythene mulch.

This work is an attempt to clarify the effect of climatic changes on pomegranate trees under irrigation regimes and soil management conditions through mulching treatments and on improving water use efficiency, water economy and productivity of pomegranate grown in sandy soils.

2. Materials and methods

This investigation was carried out during the three successive seasons of 2008, 2009 and 2010 to study the effect of climatic changes on yield and water use of pomegranate trees at El-Maghara area under some irrigation intervals (IF): (2, 4 and 6 days) and soil management (SM) conditions through mulching treatments viz: Control Without Mulch (CWM), petroleum as Bitumen Emulsion Mulch (BEM) and plant residues as Olive Pomace Mulch (OPM).

El-Maghara Experimental Station, of the Desert Research Center located in North Sinai Governorate, Egypt (latitude 30.35 N, longitude 33.20 E and 200 meter above sea level). The used climatic data of El-Maghara area were collected from the meteorological station in these station, to calculate reference evapotranspiration (ETo) using Penman–Monteith equation by using CROPWAT, software version 5.7 (Smith, 1992). Maximum and minimum air temperature, wind speed, relative humidity, sun shine hours, total rain and reference evapotranspiration are presented in (Table 1).

Seventy two healthy "Manfalouty" pomegranate trees (*Punica granatum. L*) about 9 years – old nearly moderate vigor and productivity planted in sandy soil (mechanical and chemical analyses are shown in Tables 2a,b) were determined according to Richards (1954). Water of artesian well was pumped from a depth of 288 m in El-Maghara area of Sinai and used for irrigation by drip irrigation system.

Table (1). Measured climatic data of EL–Maghara region during the period of ten years from 1998-2007.

Elements	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Avg.
Max. temp. (^oC)	19.15	20.72	22.64	24.81	28.45	32.17	34.08	34.07	30.61	27.82	24.63	21.49	26.72
Min. temp. (^oC)	4.54	4.97	7.22	9.87	12.63	15.87	18.25	18.79	15.95	12.84	9.94	6.60	11.46
Relative Humidity %	80.90	77.90	76.44	73.48	75.49	76.35	75.72	76.90	75.84	77.29	77.45	75.80	76.63
Wind speed (km/day)	177.91	184.25	215.02	209.80	192.05	173.45	160.18	165.46	154.85	166.22	173.76	174.07	178.92
Sunshine hours (hr)	7.55	7.98	8.18	9.43	10.79	12.53	12.30	11.31	10.42	9.14	7.71	6.94	9.52
Total Rain (mm)	4.53	5.38	2.11	0.41	0.26	0.00	0.00	0.00	0.00	2.95	7.87	11.51	35.01
Potential evapotranspiration (mm/day)	2.09	2.68	3.51	4.40	5.21	6.06	6.23	5.84	4.79	3.63	2.70	2.24	4.11

Table (2a). Some physical properties of the experimental soil site.

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	Infiltration rate	
	Coarse sand	Fine sand	Silt	Clay						Field capacity	Wilting point	%	cm/hr	Class
0-30	0.00	98.00	1.00	1.00	Sand	2.65	1.55	41.51	0.24	10.23	4.45	5.88	32.65	Very rapid
30-60	0.00	98.50	0.80	0.70	Sand	2.63	1.58	39.92	0.23	9.98	4.51	5.67		
60-90	0.00	99.00	0.50	0.50	Sand	2.64	1.60	39.39	0.19	10.35	4.64	5.65		
90-120	0.00	98.50	0.70	0.80	Sand	2.65	1.57	40.75	0.28	9.87	4.41	5.56		
120-150	0.00	99.50	0.30	0.20	Sand	2.63	1.56	40.68	0.22	10.18	4.39	5.45		

Table (2b). Some chemical properties of the experimental soil site.

Soil depth (cm)	CaO_3 (%)	P^H soil paste	E.Ce (dSm^{-1})	Soluble cations (me/l)				Soluble anions (me/l)			
				Ca^{++}	Mg^{++}	Na^+	K^+	$CO_3^=$	HCO_3^-	$SO_4^=$	Cl^-
0-30	5.89	7.70	0.60	2.50	1.50	1.26	0.05	_	1.80	2.11	1.40
30-60	3.80	7.70	0.70	3.00	2.00	1.57	0.08	_	1.80	2.85	2.00
60-90	4.35	7.40	1.10	3.50	2.00	3.04	0.05		2.40	2.09	6.10
90-120	5.98	7.60	1.20	3.50	2.50	4.04	0.03		3.00	1.97	5.10
120-150	4.44	7.60	0.60	2.50	1.50	1.56	0.03	_	2.40	1.09	2.10

P^H: Acidity E.C.: Electrical conductivity dSm^{-1}: decimenz per meter me/l: mille equivalent per liter

The quality of tested irrigation water used in this study is presented in (Table, 3). Saline ground water (about 2800 to 3200 ppm) was used for irrigation viz drip system. The analysis of irrigation water belongs to high salinity, medium sodium, i.e., C_4S_2 water class (Richards, 1954). It is also evident that water quality of such source shows a pronounced variation throughout the year being of higher salinity in summer than in winter.

Table (3). Chemical analysis of the irrigation water.

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	8.12	2805.14	4.38	9.02	-10.5	2670.91	Ppm.	228.46	42.30	565.80	26.98	863.53	0	268.44	1546.57	126.59	1807.38	C_4 S_2
							Epm.	11.40	3.48	24.60	0.69	40.17	0	4.40	32.20	3.57	40.17	
							%	28.38	8.66	61.24	1.72	100.0	0	10.95	80.16	8.89	100.0	
Summer	8.36	3194.76	4.99	8.19	-11.7	2967.81	Ppm.	267.13	70.26	582.59	44.97	964.94	0	453.91	1616.69	159.22	2002.86	C_4 S_2
							Epm.	13.33	5.78	25.33	1.15	45.59	0	7.44	33.66	4.49	45.59	
							%	29.24	12.68	55.56	2.52	100.0	0	16.32	73.83	9.85	100.0	

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

Irrigation treatments were applied from 1st February and continued until September 20th, then stopped until harvest date October 5th, after that completed irrigation until the end of October for three seasons and were programmed according to irrigation intervals proposed during the afternoon based on calculation of water requirements for irrigation water applied, based on climatic data obtained from the meteorological station of El-Maghara average ten years (1998-2007) table (1).

In the winter (beginning of February), a mulch practice was done by using different materials, such as olive pomace (Table 4a), bitumen emulsion (Table 4b) and control with bare soil (no-mulching). The soil around pomegranate trees were removed by hand hoeing to the depth of about 15 cm in the beginning of February, then adding olive pomace from olive portion of pulp. While, bitumen emulsion was applied on soil surface around the trunk of pomegranate trees in a circle of 1.5 m half diameter.

Table 4a. Chemical analysis of olive pomace.

Organic Mater (%)	C/N Ratio (%)	Moisture (%)	N (%)	P (%)	K (%)	Ca (%)
40.0	11.32	22.6	3.0	0.08	0.47	0.47

Table 4b. Physical and Chemical Properties of Bitumen Emulsion

Chemical name(s):	Cationic: KSS60 + 65; Anionic: SS60; Feltec 60/3 + 60/5 KRS60, 65 + 70; KMS 60 + 65; FS60 + 65
pH:	2 to 2.4 - Anionic - Basic nature Cationic - Acid nature
Boiling point/range:	100°C (Contains 40% water)
Melting point/range:	Liquid at ambient temperature
Explosive properties:	Potentially low
Density at 20°C, kg/ℓ	1,0 gm/cm3 at 25°C
Solubility - water:	Highly soluble
Solubility - solvents:	Soluble
Viscosity	@ 40°C, mm2/s: Base bitumen - 2000 AMU
Protonated amine	70 wt.%
Ammonium salt	30 wt.%

All trees received the recommended doses of organic manure in winter, 15-20 m^3/fed (25 kg/tree) and mineral fertilization of (NPK): 100-200 kg/fed ammonium nitrate in two doses in March and May after the fruit eased, 75 to 100 kg/fed calcium superphosphate and from 50 to 75 kg/fed potassium sulfate in March), respectively.

The amount of irrigation water was calculated without addition leaching requirements using the equation of Doorenbos and Pruitt (1984) and Kaller and Bliesner (1990):

D_{iw} = ((ETo X Kc X Cr X No. T.) / Ea) - Pe.

Where: D_{iw} = Applied irrigation water (liter/tree/day)
ETo = Potential evapotranspiration (mm / day)
Kc = Crop coefficient from FAO_{56}.
Cr = Canopy cover represented by the shadow area 1.5 m half diameter under trees at mid-day which in average = 7.07 m^2.
No. T. = No. of trees/fed = 324 tree.
Ea = Irrigation system efficiency (%) = 85 % for drip irrigation.
Pe = Effective rainfall (mm) = 0.30 rainfall.
The amounts of applied irrigation water are shown in table (5).

Table (5). Irrigation water applied to pomegranate trees grown in El-Maghara area.

Items	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sep.	Oct.	Season
ETo (mm/day) avg.10Years	2.68	3.51	4.40	5.21	6.06	6.23	5.84	4.79	3.63	4.71
Crop coefficient Kc (FAO)	0.4	0.5	0.6	0.7	0.8	0.8	0.8	0.8	0.8	0.69
W.R. (m^3/fed/day)	2.89	4.73	7.12	9.84	13.07	13.45	12.59	10.33	7.83	9.09
I.R. (m^3/fed/day)	2.65	4.64	7.10	9.83	13.07	13.45	12.59	10.33	7.71	9.04
Growing Period (days)	28	31	30	31	30	31	31	20	26	258
WR (m^3/fed/month)	81.02	146.53	213.46	305.10	392.20	416.87	390.25	206.51	203.58	2355.51
I.R. (m^3/fed/month)	74.24	143.86	212.95	304.78	392.20	416.87	390.25	206.51	200.47	2342.12
WR (liter/tree/day)	8.93	14.59	21.96	30.38	40.35	41.50	38.85	31.87	24.17	28.07
I.R. (liter/tree/day)	8.18	14.32	21.91	30.34	40.35	41.50	38.85	31.87	23.80	27.90
Irrigation Time (hour/day)	0.41	0.72	1.10	1.52	2.02	2.08	1.94	1.59	1.19	1.40

WR: Water requirements, IR: Irrigation requirements, ETo: Potential evapotranspiration, Emitters discharge 20 L/h

Soil moisture was measured with both tensiometer and gravimetric method at depths of 0 - 30, 30 - 60 and 60 - 90 cm. The values of soil moisture content which gravimetrically determined were employed for calculating the crop water consumptive use using Doorenbos and Pruitt (1984) equation as follows:

$ETa = (M._2 \% - M._1 \%) \times d_b \times D \times 1000$ 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).

Crop water use efficiency (WUE) 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 calculated from ETo avg. 10 years and Kc FAO) according to Allen *et al*. (1998). Irrigation water use efficiency coefficient (IWUE) was calculated by dividing the actual evapotranspiration (ETa) by the applied irrigation water (Diw) as reported by Norman *et al.*, (1998). At the end of the experiments, pomegranate yield was recorded. Moreover, in the three seasons, the fruit of each treated trees were harvest on 5th October, then fruits were counted and weighed in kg. Data were statistically analyzed using Snedecor and Cochran (1989). Investment Ratio (IR) = (total revenue, LE / total cost, LE) according to Rana *et al.* (1996).

3- Results and Discussion

3.1. Detection of Climatic Changes:

EL–Maghara region, about 90 Km south El-Arish city, North Sinai Governorate, Egypt, with altitude of about 200 meter above sea level, latitude 30°35` N. and longitude 33°20` E. Olive, guava, pomegranate trees and some vegetables, medicinal and aromatic plants are grown in the area.

The climatic change is nowadays one of the highest negotiable issues through either scientific reports or multimedia. Meanwhile, there is no unique vision about this issue as some of scientists believe that changes going toward increasing global temperature, while others referring that to the traditional meteorological cycle of cooling and heating. However, majority of negotiations are dealing with the required precautions in face to the worming phenomenon up to the studied simulation models.

Therefore, meteorological data were collected for a period of 30 years (1961-1990) as well as meteorological data of recent period of 10 years (1998-2007) of the studied area in order to detect the occurrence of changes in the different climatic elements.

Meteorological data for about 30 years (1961-1990) of EL–Maghara region (Table 6a) were collected from the Climatic Atlas of Egypt (1996) and compared with measured climatic data of EL–Maghara region during the ten years period from 1998-2007 (Table 1).

Table (6_a). Meteorological data for about 30 years (1961-1990) of EL–Maghara region.

Elements avg. 30 years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average
Max. Temperature (°C)	17.5	17.5	22.5	27.5	30.0	32.5	32.5	32.5	32.5	27.5	25.0	20.0	26.46
Min. Temperature (°C)	7.5	7.5	7.5	12.5	15.0	17.5	20.0	22.5	17.5	15.0	12.5	7.5	13.54
Relative Humidity (%)	65.0	60.0	60.0	55.0	50.0	50.0	50.0	60.0	55.0	65.0	60.0	60.0	57.50
Wind speed (km/day)	172.40	176.61	210.24	208.67	185.52	167.47	157.63	163.87	150.00	166.40	173.23	169.52	175.13
Sunshine hours (hr)	7.70	8.20	8.30	9.60	10.90	12.60	12.40	11.40	10.60	9.30	7.80	7.00	9.65
Total Rain (mm)	10.0	10.0	10.0	5.0	1.0	0.0	0.0	0.0	0.0	5.0	10.0	10.0	61.00
Potential evapotranspiration (mm/day)	2.18	2.72	3.89	5.22	6.09	6.70	6.60	6.05	5.40	3.90	3.09	2.45	4.52

Meteorological data for the three studied years (2008, 2009 and 2010) of EL–Maghara region (Table 6_b) were summarized as follow:

Table (6_b). Meteorological data for 2008, 2009 and 2010 years of EL–Maghara region.

Elements 2008	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Max. Temperature (°C)	16.60	16.57	21.85	23.17	29.19	35.2	36.33	36.63	33.66	30.64	27.68	21.27	27.40
Min. Temperature (°C)	3.38	4.11	7.17	9.25	13.36	17.97	20.42	20.02	17.17	14.34	10.78	6.86	12.07
Relative Humidity (%)	78.16	77.43	73.22	63.26	66.09	65.26	58.33	62.03	63.34	67.29	73.16	68.31	67.99
Wind speed (km/day)	141.8	173.8	190.6	203.8	140.6	146.2	139.0	168.2	156.0	181.7	140.9	150.70	161.10
Sunshine hours (hr)	7.27	7.72	7.78	9.01	10.25	11.86	11.66	10.67	9.94	8.71	7.31	6.58	9.06
Total Rain (mm)	5.68	10.24	3.21	0	0	0	0	0	0	3.65	4.36	5.20	32.34
Potential evapotranspiration (mm/day)	1.84	2.23	3.29	4.39	5.09	6.34	6.60	6.44	5.35	4.24	2.87	2.28	4.25
Elements 2009	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Average**
Max. Temperature (°C)	17.64	17.63	22.93	24.24	30.56	33.55	35.89	36.44	32.56	30.05	28.98	22.32	27.73
Min. Temperature (°C)	4.08	4.87	8.08	10.48	14.73	18.11	20.61	19.78	17.07	14.36	12.89	6.05	12.59
Relative Humidity (%)	78.5	77.22	81.27	73.09	79.16	81.68	77.54	71.08	62.99	67.85	67.46	64.01	73.49
Wind speed (km/day)	202.7	198.2	203.9	245.1	208.9	180.7	164.2	171.5	178.2	155.8	180.2	145.20	186.22
Sunshine hours (hr)	7.20	7.64	7.7	8.92	10.15	11.75	11.54	10.56	9.84	8.62	7.23	6.51	8.97
Total Rain (mm)	3.19	3.04	0	0	0	0	0	0	0	0	0	1.67	7.90
Potential evapotranspiration (mm/day)	2.10	2.39	3.23	4.38	5.29	6.01	6.31	6.22	5.40	3.94	3.31	2.48	4.25
Elements 2010	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Average**
Max. Temperature (°C)	18.78	21.15	24.48	25.37	26.89	31.23	34.87	34.88	30.3	29.3	26.11	22.28	27.14
Min. Temperature (°C)	3.83	5.24	8.04	10.13	12.31	15.94	19.6	19.06	15.46	13.71	10.17	7.19	11.72
Relative Humidity (%)	67.63	66.83	68.63	70.33	71.33	72.13	68.63	70.33	64.69	60.92	71.38	68.13	68.41
Wind speed (km/day)	96.34	146.9	271.7	126.8	153.8	135.0	142.1	197.4	128.8	142.9	184.2	241.90	163.99
Sunshine hours (hr)	8.00	8.54	8.67	10.02	11.36	13.12	12.92	11.91	11.06	9.72	8.15	7.30	10.06
Total Rain (mm)	4.28	1.47	0	0	0	0	0	0	0	3.00	6.00	15.00	29.75
Potential evapotranspiration (mm/day)	1.93	2.76	4.26	4.29	5.07	5.91	6.46	6.46	4.92	3.96	3.10	2.87	4.33

To compare the results of average climate values, table (**6_c**) shows the results compared to the values of the average climate data of the studied area for a period of 30 years (1961-1990), 13 years (1998-2010), 10 years (1998-2007), 3 years (2008-2010), and the actual values of years 2008, 2009 and 2010, as the data show the following:

Table (6_c) Comparison between meteorological data of the studied three years and both average 10 and 30 years of El-Maghara area.

Differences	Comparison with 10 years (1998-2007)				Comparison with 30 years (1961-1990)					
Meteorological elements	**2008**	**2009**	**2010**	**3 years (2008-2010)**	**2008**	**2009**	**2010**	**3 years (2008-2010)**	**10 years (1998-2007)**	**13 years (1998-2010)**
Max. Temperature (°C)	0.68	1.01	0.42	0.70	0.94	1.27	0.68	0.96	0.26	0.42
Min. Temperature (°C)	0.61	1.13	0.26	0.67	-1.47	-0.95	-1.82	-1.41	-2.08	-1.93
Relative Humidity (%)	-8.64	-3.14	-8.22	-6.66	10.49	15.99	10.91	12.46	19.13	17.59
Wind speed (km/day)	-17.81	7.30	-14.93	-8.48	-14.02	11.09	-11.14	-4.69	3.79	1.83
Sunshine hours (hr)	-0.46	-0.55	0.54	-0.16	-0.59	-0.68	0.41	-0.28	-0.13	-0.16
Total Rain (mm/year)	-2.67	-27.11	-5.26	-11.68	-28.66	-53.10	-31.25	-37.67	-25.99	-28.68
Potential evapotranspiration (mm/day)	0.14	0.15	0.22	0.16	-0.27	-0.27	-0.19	-0.24	-0.41	-0.37

To detect the variations in meteorological elements among the three sets of collected data; i.e. 30 years (Table 6_a), 10 years (Table 1) and the last 3 years (Table 6_b), the last table show these comparisons. From the table it can conclude to the following:

1. Remarkable increase in average maximum temperature values when comparing the three years values of 2008, 2009 and 2010 with corresponding ones of both average 10 and 30 years bases which could be contributed to the enhance in growth parameters (Supit *et al.*, 2010).
2. Remarkable decrease in average minimum temperature values for the three years of 2008, 2009 and 2010 only when compared with 30

years, while fluctuated on 10 years base. This is clearly reflected on achieving the needed chilling hour's requirements which help in breaking the dormancy phase (actually ranged between 250 and 400 hours) (Sheets *et al.,* 2008) compared with the reference one which is between 100-200 hours.

3. The net result of 1 and 2 is wider temperature range of fluctuation for the last years 2008-2010 which reflect partial continental phenomena (Stefan *et al.,* 2007).
4. The relative humidity values become higher when compare the last 3 years 2008-2010 with 30 years data; while lower when compare with 10 years values (Peter et *al.,* 2005).
5. Generally, the wind speed values of the last 3 years 2008-2010 tend to be lower than both 10 and 30 years values.
6. Generally, the rainfall of the last 3 years 2008-2010 give lower values on both bases of 10 and 30 years values (IPCC, 2007).
7. The net conclusion of all elements on reference evapotranspiration (ETo) values for the last 3 years 2008-2010 give contradictory trends being lower than average 30 years (may be due to higher relative humidity values), while higher than the 10 years values (may be due to lower relative humidity values) (IPCC, 2007).
8. The last two columns in table (6c) define the "Oasis effect" for the experimental site through the following:
   - a- Definite increase in average maximum temperature values (IPCC, 2007).
   - b- Definite decrease in average minimum temperature values, therefore definite wide temperature range (IPCC, 2007).
   - c- Sensible increase in average relative humidity values (IPCC, 2007).
   - d- Clear decrease in average rainfall values (IPCC, 2007).
   - e- Clear decrease in potential evapotranspiration (ETo) (IPCC, 2007).

From all these observations it can conclude to sensible climate variations for the site which should be faced by proper irrigation application which is the main target of this research. Not worthy to mention that the studied area is a typical site for the "Oasis effect" criteria as the cultivated site is surrounded by mountainous heights which cause heat convection to the cultivated core of the area. So, blowing of the wind loaded with high temperature in the waves caused a rise in the values of evapotranspiration at the edges of the region and cold the core of the cultivated areas (Sheets *et al.,* 2008) and (Peter et *al.,* 2005). Furthermore increasing the values of relative humidity and reducing the values of evapotranspiration within the studied region (Supit *et al.,* 2010). Peter et *al.,* (2005) and Stefan *et al.,* (2007) they found that altitude and surrounding by mountains have a large effect on crop evapotranspiration. Therefore, as they conclude, resolution of land use data and digital elevation models would be needed to reliable model irrigation water requirements for larger regions or the entire country of Oman.

On global base, there are climate changes slightly each year, which can forecast an increase in the average air temperature by about 3 degrees Celsius during the next hundred years, which need several efforts to mitigate and adapt to projected climate change. (IPCC, 2007) pointed out to the global climatic change, and further changes are expected regardless of the efforts to reduce global emissions of atmospheric CO_2 which increased from an industrial concentration of 280 to 379 ppm in 2005 (IPCC, 2007).

The product of these variations reflects a definite decrease in both potential and actual evapotranspiration mean values (ETo & ETa) for the site under the pomegranate trees.

9. From the horticulture point of view, the pomegranate trees enhance production with wider temperature ranges which is clearly noticed in table (6_c). Furthermore, it needs sufficient chilling hours through winter season (October – March) which also detected from the recorded meteorological data as shown in table (6_b) as previously mentioned in point 2.

Interrelation among both potential and actual evapotranspiration, crop production and water use efficiency:

Table (6_d) Data of average potential evapotranspiration, actual evapotranspiration, pomegranate yield and water use efficiency for the studied three years (2008-2010).

Growing seasons	2008	2009	2010	Average
Potential Evapotranspiration ETo (m^3/fed)	2887.04	2833.41	2894.46	2871.64
Actual Evapotranspiration ETa (m^3/fed)	1870.46	1911.52	1966.12	1916.03
Fruit Yield (kg/fed)	6227.28	7019.68	7855.35	7034.10
Water Use Efficiency (kg/m^3)	3.36	3.70	4.02	3.69

The data in table (6_d) indicate the following:

a- Fluctuation of ETo average data over the studied years from 2008-2010.

b- Successive increase in ETa average values indicating definite effect of climate changes, which discussed before, an enhancing the growth of pomegranate trees.

c- The general results, despite the effect of treatments, in gradual significant increase in pomegranate production over the three years. However the cumulative increase in trees production through 2008 to 2010 reaches about 23%.

3.2. Actual Evapotranspiration (ETa):

EL–Maghara area affected by the phenomenon of what is known "Oasis effect" as it surrounded by mountains and dry desert areas as mentioned before.

Data presented in table (7) show a significant decrease in actual evapotranspiration (water consumptive use) with increasing irrigation intervals, but exhibit highly significant decrease in water consumptive use under olive pomace mulch (OPM) for pomegranate trees. The data also show significant interaction between the applied 6 days irrigation interval and olive pomace mulch (OPM) treatment. Water consumptive use of pomegranate increased by progress of the trees age. Table (7) gives the daily actual evapotranspiration values (liter/tree/day) as detected by field measurements throughout the growth three seasons.

Comparing the values of water consumption under olive pomace mulch and bitumen emulsion mulch shows the following:

i- Dark color of bitumen emulsion mulch enhance heat reservation under trees canopy, so providing sufficient energy to processes and conditions related to plant growth. These include movement and uptake of soil water and nutrients, chemical and biological reactions, microbial activities, root growth …..etc.

ii- Evaporation has been highly retarded under olive pomace mulch than that under bitumen emulsion layer as the former can catch moisture than the latter.

iii- It is also noticed that the control plots suffered from weed growth which consume some of the added water, so the residual for trees decreased than planned amount, thereby plant growth appreciably decreased.

Similar results were obtained by Hasan et al., (2002) who found that the total water consumption and water use efficiency were highest under the highest soil moisture regime with black polythene mulch. Seidhom and Evon (2006) found that, mulching significantly reduce evaporation losses.

Table (7). Actual evapotranspiration (liter/tree/day) of pomegranate grown in El-Maghara region.

I.F.	S. M.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	liter/tree /day	liter/tree /season	m^3/tree /season	m^3/fed
2 (days) a	CWM	7.00	10.94	18.38	26.02	34.29	35.32	33.26	27.09	18.86	23.46	6080.01	6.08 a	1969.92
	BEM	6.79	10.48	16.87	25.52	33.94	34.95	32.92	26.81	18.66	22.99	5955.76	5.96 b	1929.67
	OPM	6.50	10.15	16.12	25.10	33.30	34.30	32.30	26.31	18.31	22.49	5824.37	5.82 c	1887.10
4 (days) b	CWM	6.86	10.13	15.77	25.59	33.87	34.88	32.85	26.75	18.63	22.81	5907.48	5.91 a	1914.02
	BEM	6.58	9.83	15.55	24.89	33.31	34.31	32.31	26.31	18.32	22.38	5793.70	5.79 b	1877.16
	OPM	6.36	9.54	15.30	24.39	31.75	32.70	30.80	25.08	17.46	21.49	5565.52	5.57 c	1803.23
6 (days) c	CWM	6.72	9.90	16.04	25.03	33.16	34.15	32.16	26.19	18.24	22.40	5800.34	5.80 a	1879.31
	BEM	6.50	9.76	15.47	24.04	32.06	33.03	31.10	25.33	17.63	21.66	5608.85	5.61 b	1817.27
	OPM	6.22	9.25	14.93	23.54	30.92	31.85	29.99	24.43	17.01	20.90	5413.98	5.41 c	1754.13
Avg.2008		**6.61**	**10.00**	**16.05**	**24.90**	**32.95**	**33.94**	**31.97**	**26.03**	**18.12**	**22.29**	**5772.22**	**5.77**	**1870.20**
2 (days) a	CWM	7.14	11.36	18.52	26.65	35.35	36.41	34.29	27.93	19.44	24.12	6250.36	6.25 a	2025.12
	BEM	6.93	10.81	17.07	26.09	34.50	35.54	33.47	27.26	18.98	23.40	6062.70	6.06 b	1964.31
	OPM	6.65	10.48	16.26	25.52	33.87	34.88	32.85	26.75	18.63	22.88	5924.97	5.92 c	1919.69
4 (days) b	CWM	6.93	11.17	17.11	26.16	34.22	35.25	33.19	27.03	18.82	23.32	6042.52	6.04 a	1957.78
	BEM	6.72	10.61	15.86	25.59	33.30	34.30	32.30	26.31	18.31	22.59	5851.96	5.85 b	1896.04
	OPM	6.50	10.04	14.69	25.10	32.45	33.42	31.48	25.64	17.85	21.91	5674.49	5.67 c	1838.54
6 (days) c	CWM	6.79	10.96	16.16	25.52	33.65	34.66	32.64	26.59	18.51	22.83	5914.92	5.91 a	1916.43
	BEM	6.65	10.32	15.57	24.96	32.88	33.86	31.89	25.97	18.08	22.24	5761.02	5.76 b	1866.57
	OPM	6.43	9.97	14.98	24.46	32.03	32.99	31.07	25.30	17.61	21.65	5607.47	5.61 c	1816.82
Avg.2009		**6.75**	**10.64**	**16.25**	**25.56**	**33.58**	**34.59**	**32.58**	**26.53**	**18.47**	**22.77**	**5898.94**	**5.90**	**1911.26**
2 (days) a	CWM	7.35	12.80	18.88	26.94	36.27	37.36	35.18	28.65	19.95	24.82	6432.38	6.43 a	2084.09
	BEM	7.07	12.44	17.85	26.72	35.21	36.26	34.15	27.81	19.36	24.10	6246.57	6.25 b	2023.89
	OPM	6.86	12.16	17.18	26.01	34.43	35.46	33.40	27.20	18.94	23.52	6094.86	6.09 c	1974.73
4 (days) b	CWM	7.07	12.54	17.06	26.87	34.78	35.83	33.74	27.48	19.13	23.83	6178.29	6.18 a	2001.77
	BEM	6.79	12.08	16.75	25.64	34.08	35.10	33.06	26.92	18.74	23.24	6022.97	6.02 b	1951.44
	OPM	6.58	11.69	16.44	25.31	33.16	34.15	32.16	26.20	18.24	22.66	5872.92	5.87 c	1902.83
6 (days) c	CWM	6.96	12.37	17.28	25.65	34.29	35.32	33.26	27.09	18.86	23.45	6078.91	6.08 a	1969.57
	BEM	6.72	11.95	16.62	25.17	33.30	34.30	32.30	26.31	18.31	22.77	5903.08	5.90 b	1912.60
	OPM	6.50	11.45	16.21	24.67	32.66	33.64	31.68	25.80	17.96	22.29	5776.70	5.78 c	1871.65
Avg.2010		**6.88**	**12.16**	**17.14**	**25.89**	**34.24**	**35.27**	**33.22**	**27.05**	**18.83**	**23.41**	**6067.41**	**6.07**	**1965.84**

(IF): irrigation intervals, (SM): soil management, (CWM): Control Without Mulch, (BEM): Bitumen Emulsion Mulch, (OPM): Olive Pomace Mulch. $L.S.D._{0.05}$: Intervals = 0.052, 0.059 & 0.048 & Mulch = 0.025, 0.026 & 0.022 for 3 seasons, respectively. a, b, c significant differences.

3.3. Fruit Pomegranate Yield:

Supit *et al.*, (2010) found that the recent changes in the simulated potential crop yield and biomass production were caused by changes in the temperature and examined global radiation patterns, using the Crop Growth Monitoring System.

It is quite evident from table (8) that the tree yield increased significantly with increasing irrigation intervals. The higher value of tree yield was achieved by irrigated trees at 6 days, followed by 4 days. While, the interval 2 days recorded the lowest values of tree yield. The results go in line with those reported by Abou-Aziz *et al.*, (1995), Afria *et al.*, (1998) and Sheets *et al.*, (2008) witch noticed that when soil reached 60 or 40% of field capacity, irrigation regime were resulted in the highest pomegranate fruit numbers and yields.

Table (8). Fruit yield of pomegranate crop grown in El-Maghara region.

Irrigation Intervals	Soil Management	1 st. season (2008)		2 nd. season (2009)		3 rd. season (2010)	
		kg/tree	kg/fed	kg/tree	kg/fed	kg/tree	kg/fed
2 (days) b	CWM	13.81	4475.25 c	15.75	5101.79 c	18.65	6041.59 b
	BEM	15.45	5005.80 b	17.61	5706.61 b	23.64	7658.87 a
	OPM	18.61	6029.64 a	21.96	7115.01 a	25.12	8140.01 a
4 (days) ab	CWM	15.56	5042.25 c	17.74	5748.17 c	18.83	6101.12 b
	BEM	21.05	6820.20 b	24.00	7775.03 b	25.47	8252.44 a
	OPM	22.50	7290.00 a	25.65	8310.60 a	27.23	8820.90 a
6 (days) a	CWM	15.00	4860.00 c	17.10	5540.40 c	19.41	6287.22 b
	BEM	20.92	6778.08 b	23.85	7727.01 b	27.20	8813.81 a
	OPM	30.08	9744.30 a	31.34	10152.54 a	32.66	10582.16 a
$L.S.D._{0.05}$: Intervals			1346.73		1577.39		1499.34
$L.S.D._{0.05}$: Mulch			799.66		994.45		995.03

(CWM): Control Without Mulch, (BEM): Bitumen Emulsion Mulch, (OPM): Olive Pomace Mulch & a, b, c significant differences.

In relation to the specific effect of soil management the olive pomace mulched trees showed to be most effective treatments in tree yield, followed by bitumen mulched trees as compared with unmulched trees (control) (table 8). The same results were obtained by Patra *et al.*, (2004) who found that all the mulching treatments resulted in higher yield per hectare compared to the control. The same trend obtained by those Singh *et al.*, (2003), Seidhom and Evon (2006) and Bakeer (2009).

Considering, the interaction effect of irrigation intervals and soil management on yield, data in Table (8) indicate that irrigated at 6 days with olive pomace mulching trees recorded the highest values of tree yield during the three seasons. However, irrigated at 2 days with non-mulching within trees gave the least values in this concern. However, pomegranate fruit yield increased by progress of the trees age.

From table (8) it is clearly noticed the following:

Irrespective to mulching treatments it is clear that yield increases upon increasing irrigation intervals. These findings may be explained by the effect of expanding irrigation period on enhancing root elongation, while mulching accelerate this result which in turn reflected on yield of trees. These findings are mainly due to stimulation of concurrent flow of water and heat and partial aeration, which increase the yield. On the other hand, data show that variation in yield due to alternate bearing and yield improved .These results are in agreement with findings of **Singh *et al.,*** (2003), Seidhom and Evon (2006) and Bakeer (2009).

3.4. Water Use Efficiency of Pomegranate Crop (W.U.E.):

Data presented in table (9) reveal that the influence of increasing irrigation intervals on WUE is significant differences. Whereas a mulch treatment significantly increases upon applying mulching treatments compared to the control (irrigation interval at 2 days without mulch). The highest value of WUE is associated with irrigation interval at 6 days by using olive pomace mulch were reached 5.55, 5.59 and 5.65 (kg/m^3) followed by using olive pomace mulch irrigated at 4 days were reached 4.04, 4.52 and 4.64 (kg/m^3) for the three seasons, respectively. WUE of pomegranate increased by progress of the trees age.

Peter et al., (2005) and Supit et al., (2010) they found two mechanisms to reduce heat and moisture exchange between the oasis and the surrounding desert: (1) the updraft over the desert reduces low-level hot, dry air flowing from the desert into the oasis; and (2) the downdraft increases the atmospheric static stability that reduces the oasis evaporation, and thus increasing WUE. However, olive pomace mulches may be associated with pronounced increases in soil temperature. So, it is suggested that this result activate both water and nutrient consumptions by root of trees which affect the crop yield. Also, may due to stimulation of concurrent flow of water and heat and partial aeration, which increase the yield. Similar results were obtained by Hasan et al., (2002) Seidhom and Evon (2006) and Bakeer (2009).

Table (9). Water use efficiency and water economy of pomegranate crop grown in El-Maghara region.

Irrigation Intervals	Soil Management	1 st. season (2008)		2 nd. season (2009)		3 rd. season (2010)	
		Water Use Efficiency (kg/m^3)	Water Economy (kg/m^3)	Water Use Efficiency (kg/m^3)	Water Economy (kg/m^3)	Water Use Efficiency (kg/m^3)	Water Economy (kg/m^3)
2 (days) c	CWM	2.27 c	1.90	2.52 c	2.17	2.90 c	2.56
	BEM	2.59 b	2.13	2.90 b	2.42	3.78 b	3.25
	OPM	3.19 a	2.56	3.71 a	3.02	4.12 a	3.46
4 (days) b	CWM	2.63 c	2.14	2.94 c	2.44	3.05 c	2.59
	BEM	3.63 b	2.90	4.10 b	3.30	4.23 b	3.50
	OPM	4.04 a	3.09	4.52 a	3.53	4.64 a	3.74
6 (days) a	CWM c	2.59 c	2.06	2.89 c	2.35	3.19 c	2.67
	BEM b	3.73 b	2.88	4.14 b	3.28	4.61 b	3.74
	OPM a	5.55 a	4.14	5.59 a	4.31	5.65 a	4.49
$L.S.D._{0.05}$: Intervals		0.135		0.125		0.093	
$L.S.D._{0.05}$: Mulch		0.105		0.103		0.097	

(CWM): Control Without Mulch, (BEM): Bitumen Emulsion Mulch, (OPM): Olive Pomace Mulch & a, b, c, significant differences.

3.5. Water Economy of Pomegranate Crop (W.E.):

Data in table (9) reveal that the same trend of water use efficiency is observed in water economy of pomegranate which increased by increasing irrigation intervals. However, for mulch treatments significant increase compared to the control (irrigation interval at 2 days without mulch). The highest value of W.E. is associated with irrigation interval at 6 days by using olive pomace mulch were reached 4.14, 4.31 and 4.49 (kg/m^3) followed by using olive pomace mulch irrigated at 4 days were reached 3.09, 3.53 and 3.74 (kg/m^3) for the three seasons, respectively. W.E. values of Pomegranate increased by progress of the trees age.

These findings may be due to saving the stored soil moisture and also to high yields, thereby high water economy values. Similar results were obtained by Hasan *et al.*, (2002) Seidhom and Evon (2006) and Bakeer (2009).

3.6. Irrigation Water Use Efficiency Coefficient (IWUE):

Many indices to assess water use performance have been used and are summarized by Purcell and Currey (2003). These indices describe the conversion of available water resources into crop yield at different stages of plant growth and thus quantify the proportion of productive water use to unproductive losses. In this study irrigation water use efficiency coefficient is computed as the ratio of actual water demand and the applied amount of irrigation water (Norman *et al.*, 1998). Irrigation water use efficiency coefficient (IWUE) of pomegranate trees decreased by increasing intervals between successive irrigation and mulching (Table, 10). Amounts of applied water will be decreased to raise the irrigation water use efficiency (IWUE), which could be considered as water saving parameter as show in table (10).

Table (10). Irrigation water use efficiency coefficient (IWUE) of pomegranate crop grown in El-Maghara region during the three seasons.

Growing seasons	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Irrigation water use
Average 2008	0.74	0.69	0.73	0.82	0.82	0.82	0.82	0.82	0.75	0.78
Average 2009	0.76	0.73	0.74	0.84	0.83	0.83	0.84	0.83	0.76	0.80
Average 2010	0.77	0.83	0.78	0.85	0.85	0.85	0.85	0.85	0.78	0.82
Annual average	0.76	0.75	0.75	0.84	0.83	0.83	0.84	0.83	0.76	0.80

Regarding the irrigation water use efficiency coefficient (IWUE), table (10) shows that the obtained values ranged between 0.63 and 0.86 with an average of 0.78 for 1st. year, 0.68 and 0.88 with an average of 0.80 for 2nd. year and 0.73 and 0.91 with an average of 0.82 for 3rd. year. These findings confirm the success of 6 days interval of irrigation than other two treatments due to low irrigation use efficiency. It is worthy to note that the efficiency of drip irrigation was assumed to have 85 % (Doorenbos and Pruitt, 1984), so adopting expanded irrigation intervals with some mulching surface application is advised to these conditions. Similar findings were stated by Farshi (2001), Stefan *et al.,* (2007) and Bakeer (2009).

3.7. Pomegranate Crop Coefficient (Kc):

Data presented in table (11) reveal that the influence of irrigation intervals on crop coefficient of pomegranate plant progressively increasing was not significant. However, significant decrease resulted by using mulch of olive pomace and bitumen compared to the control (irrigation interval at 2 days without mulch).

Table (11). Pomegranate crop coefficient (Kc) under El-Maghara conditions during the three seasons.

Growing seasons	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Kc Season
Average 2008	0.42	0.43	0.52	0.69	0.73	0.73	0.70	0.69	0.60	0.61
Average 2009	0.40	0.47	0.53	0.68	0.79	0.78	0.74	0.70	0.66	0.64
Average 2010	0.35	0.40	0.57	0.72	0.82	0.77	0.73	0.78	0.67	0.65
Annual average	0.39	0.43	0.54	0.70	0.78	0.76	0.72	0.72	0.65	0.63

Adjusting crop coefficient in suitable environmental conditions which could be considered as water saving parameter. These findings may be the decrease actual evapotranspiration due to keeping soil moisture content under mulch and thus decrease crop coefficient. Similar findings were stated by Allen *et al.*, (1998) and Seidhom and Evon (2006).

3.8. Environmental Stress Coefficient (Ks):

When cultivating crops in fields, the real crop evapotranspiration may deviate from ETc due to non – optimal conditions such as the presence of pests and diseases, soil salinity, low soil fertility, water shortage or water logging. This may result in reducing the evapotranspiration rate below ETc. Therefore, under soil water limiting conditions, Ks < 1, and where there is no soil water stress, Ks = 1. Likewise, the same trend of crop coefficient of pomegranate were observed for environmental stress coefficient which, progressively increased by increasing irrigation intervals with non significant differences and significant decrease with using mulch of bitumen and olive pomace compared to the control (irrigation interval at 2 days without mulch), table (12).

To increase water saving and decrease water loss we must modified the calculated irrigation water amounts formula by multiplying with adjusting Kc and dividing by environmental stress coefficient (Ks) and IWUE and or by for all kinds of other stresses and environmental constraints on crop evapotranspiration, then become as;

D_{iw} = ((ETo X Kc / Ks / IWUE X Cr X No. T.) /Ea) - Pe.

Table (12). Environmental stress coefficient (Ks) of pomegranate crop grown in El-Maghara region during the three seasons.

Growing seasons	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Ks Season
Average 2008	0.87	0.81	0.86	0.96	0.96	0.96	0.97	0.96	0.88	0.92
Average 2009	0.89	0.86	0.87	0.99	0.98	0.98	0.99	0.98	0.90	0.94
Average 2010	0.91	0.98	0.92	1.00	1.00	1.00	1.01	1.00	0.92	0.97
Annual average	0.89	0.88	0.88	0.99	0.98	0.98	0.99	0.98	0.90	0.94

This may be interpreted that due to decreasing actual evapotranspiration, decreased crop coefficient (Kc), thus decreased (Ks) and (IWUE) coefficients under these conditions, which could be considered as water saving parameters and suitable environmental conditions. Similar findings were reported by Allen *et al.*, (1998) and Seidhom and Evon (2006).

3.9. Economical Assessment:

The values of investment ratio (IR) are illustrated in table (13). Table (13) calculate the investment rate for the applied treatments in the experiment as a rate for investing one pound as it is calculated as following: IR = total revenue / total cost, LE. However, the modified IR values calculated depend on the modified irrigation water referring to actual evapotranspiration data. Table (13) arranges the resulted IR values for all treatments in ascending order with guidance of the national IR value which is about 2.25 for this area.

From table (13) it can be concluded the following:

1- Mulching with olive pomace gives the high values especially under 6 day's irrigation interval (3.07).
2- Bitumen emulsion mulch under 6 days irrigation interval give higher IR values regarding to olive pomace mulch under 4 and 2 days irrigation intervals respectively.

3- All treatments give higher IR values than the national one with increasing trend by increasing irrigation interval being 6 > 4 > 2 days.

These findings give a group of options which could be adapted with different conditions in the site. Similar findings were stated by Seidhom and Evon (2006) and Bakeer (2009).

Table (13). Inputs, outputs items and investment ratio (IR) of pomegranate yield grown in El-Maghara region.

Items	Soil management	2 days Irrigation Intervals			4 days Irrigation Intervals			6 days Irrigation Intervals		
		CWM	BEM	OPM	CWM	BEM	OPM	CWM	BEM	OPM
List of Inputs	land preparation, LE/fed	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
	Cultivation, LE/fed	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
	Irrigation, LE/fed	942.20	942.20	942.20	942.20	942.20	942.20	942.20	942.20	942.20
	Organic Fertilization, LE/fed	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
	Mineral Fertilization, LE/fed	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
	Mulch, LE/fed	0.00	900.00	1000.00	0.00	900.00	1000.00	0.00	900.00	1000.00
	Weed Control, LE/fed	120.00	30.00	30.00	120.00	30.00	30.00	120.00	30.00	30.00
	Pest Control, LE/fed	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
	Labors Costs, LE/fed	60.00	30.00	30.00	60.00	30.00	30.00	60.00	30.00	30.00
	Machines, LE/fed	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
	Fuel, LE/fed	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
	Harvesting, LE/fed	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	Crop Transportation, LE/fed	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	Rent (on season), LE/fed	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
	Total cost (LE/fed/season)	2572.20	3352.20	3452.20	2572.20	3352.20	3452.20	2572.20	3352.20	3452.20
List of Output	Yield, kg/fed	6041.59	7658.87	8140.01	6101.12	8252.44	8820.90	6287.22	8813.81	10582.16
	Price, LE/kg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Total revenue (LE/fed/season)	6041.59	7658.87	8140.01	6101.12	8252.44	8820.90	6287.22	8813.81	10582.16
	Total profit (LE/fed/season)	3469.38	4306.67	4687.81	3528.92	4900.24	5368.70	3715.02	5461.61	7129.96
Investment Ratio (LE/ILE)		*2.35*	*2.28*	*2.36*	*2.37*	*2.46*	*2.56*	*2.44*	*2.63*	*3.07*

(CWM): Control Without Mulch, (BEM): Bitumen Emulsion Mulch, (OPM): Olive Pomace Mulch. 0.40 LE/m^3 irrigation water

4- Conclusion

From the above mentioned discussion it can be conclude to the following:

1. There is a detected local climatic change for the main meteorological data of the site compared either with 10 or 30 years recorded data. These changes are partially caused by the global climatic change in one hand and to the local Oasis effect in the site in the other hand. These changes play a positive role in enhancing the yield of pomegranate trees referring to the horticulture references.
2. Enlarging the irrigation intervals from 2 to 6 days cause a gradual increase in such yield as it seems to enhance root elongation, so the shoot growth as well.
3. Saving irrigation water could be enhanced by using olive pomace mulch more than that achieved by bitumen emulsion mulch, while both were higher than that of unmulched trees.
4. In all cases, the applied treatment get higher investment ratios (IR) than the traditional one (2.25 LE/IL), but mulching with olive pomace engaged with 6 days irrigation interval give the highest IR value among all the tested interactions.

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