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EFFECT OF DIFFERENT WATER QUANTITIES ON GROWTH AND FRUIT QUALITY OF OLIVE TREES UNDER NEW RECLAIMED LANDS CONDITIONS

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ABSTRACT

A field experiment was conducted during two successive seasons (2014 and 2015) in a private orchard farm, located at the ٦4 km on the Cairo-Alexandria Desert Road, to study the effect of different irrigation levels, irrigation methods and olive cultivars on plant growth and yield of olive trees(*Olea europara*, L.). Treatments were: a- three irrigation levels: 4384 m^3/feddan(100%), 3740 m^3/feddans (85%) and 3089 m^3/feddan (70%); b- two drip irrigation methods: on-line surface irrigation and in-line sub surface irrigation and c- two olive cultivars, Picual and Manzanillo. The experiment was designed in a split-split plot with three replicates. Estimated irrigation water was calculated, using FAO method, in order to compare between applied and estimated irrigation regime.

Data revealed that using 3740m^3/fed irrigation level gave the highest growth and yield compared with other treatments. The Estimated irrigation water was close to applied treatment 3740 m^3/fed. In-line (surface irrigation) method recorded the highest yield and oil during the two successive seasons. The oil content in fruit increased with water decrease. The Picual cultivar showed the highest oil content while, Manzanillo cultivar gave the highest yield. The interaction between the three tested factors show that the 3740m^3/fed treatment with the In-line surface irrigation combined with Manzanillo cultivar was the best combined treatment. The highest WUE was found in 3089 m^3/ fed. with subsurface irrigation combined with Manzanillo cultivar.

Keywords: Olive cultivars, applied irrigation methods and irrigation levels

INTRODUCTION

The olive tree (*Olea europaea* L.) is distinguished by high resistance to intense drought with suitable production Conner *et al.* (2005). Though traditional olive trees grow under drought conditions. Several studies have shown that irrigation has a large effect on the productivity of olive farms (Girona*et al*., 2002). An ideal water supply to olive farms is fundamental to ensure the growth processes and tree production (Anabela *et al*., 2010). Infect, differences highlighted between cultivars in water relation and water use efficiency proposed that cultivar – specific irrigation time table could decrease management costs (Tognetti *et al*., 2002). Seeking for improved water usage efficiency, there has been growing interest in the application of regulated deficit irrigation (RDI) management techniques, which decrease the amount of water consumed (Goldhamer, 1999 and Puertas & Trentacoste 2011). On the other hand, determining the water needs of olive farms is a subject of primary important. On the other hand, environmental conditions play a vital role in growth and productivity of olive cultivars as productivity varies according to environment and climatic conditions (Abdel Ghani *et al.,* 2013).

At present, olive growing areas suffer from competition for water with other crops making the future of olive plantations in the Mediterranean countries and global change scenario predicting climatic and land use changes (including a general increase in water demand), makes us to study how to save water while maintaining yield (Tognetti *et al.,* 2006 and Sebastiani *et al*., 2012). In spite of the importance of both crop capacity and tree water needs for fruit development the interaction between these two factors has seldom been studied and remains poorly understood (Gucci, 2014).

The aim of the present study was to investigate the effect of different water levels on the production of two olive cultivars in sandy soil and the response of trees to different irrigation systems.

MATERIALS AND METHODS

Experimental Site

The field experiment was conducted in a private olive (*Olea europara*, L.) orchard at 64km Cairo-Alexandria Desert Road during the two growing seasons 2013/2014 and 2014/2015.The two cultivars used, Picual and Manzanillo, were grown under drip irrigation system. The trees were planted 6 x 3 m apart (233 tree /feddan), irrigated from a deep well and received the standard horticultural management applications. Proper healthy, uniform and regular 66 bearing olive trees, distributed on six rows (each row contained 11 trees), were selected for this study.

Treatments

The experiment contained three factors: a- three irrigation levels (100%" 4384 m^3/feddan", 85% "3740 m^3/feddan" and 70%"3089m^3/feddan");b- two applied irrigation methods (in-line GR drip irrigation and on-line drippers under 10 cm depth) and c-two olive cultivars (Picual and Manzanillo).

The irrigation levels were applied by installing a flow-meter and a valve to control the applied water quantity for both drip irrigation techniques. The flow-meter was connected with proper fittings to distribute water for the different irrigation levels. Each irrigation level treatment has one flow-meter to record the applied water for both irrigation methods (in-line GR drip surface irrigation and on-line drippers under 5 cm depth sub-surface irrigation). The irrigation time was 3.5h for 100%, 3 h for 85% and 2.5h for 70%. The olive trees were irrigated with 12 and 6 drippers/tree depend on applied irrigation methods and irrigation scheme as follows: November, December, January, and February: two times/week; March, April, September, October: three times/week, May, June: five times/week and July, August: six times/week.

The in-line GR drip irrigation (surface irrigation) was applied in three rows of olive trees each row had two GR drip irrigation lines in the drip irrigation treatment. The distance between each two drippers was 50 cm and the dripper discharge was 4 l/h. Each tree has 12 drippers in both sides and total discharge was 48 l/h.

The on-line drippers (sub surface irrigation) under 10 cm depth was established by installing four on-line drippers per tree; proper spaghetti tube was used to connect the drippers with the polyethylene line. The dripper discharge was 8 l/h. Each tree has 6 drippers in both sides and total discharge was also48 l/h. The drip irrigation technique under ten cm depth was applied by the installation of vertical PVC pipe (50 mm diameter) into the soil ten cm. depth hole and install the dripper inside this pipe so that the water distribute down under the soil surface. Both of in-line and on-line irrigation techniques were discharging the same quantity of water.

Climate data

The daily maximum and minimum temperature and relative humidity were recorded by a Data logger Model SK-L200THIIα. Other climate factors (wind speed, precipitation and solar radiation) were collected from automated weather station to calculated Reference Evapotranspiration (ETo). The Reference Evapotranspiration (ETo) was calculated using Food and Agricultural Organization (FAO) Penman-Monteith (PM) procedure, FAO 56 method, presented by (Alln, 1998).

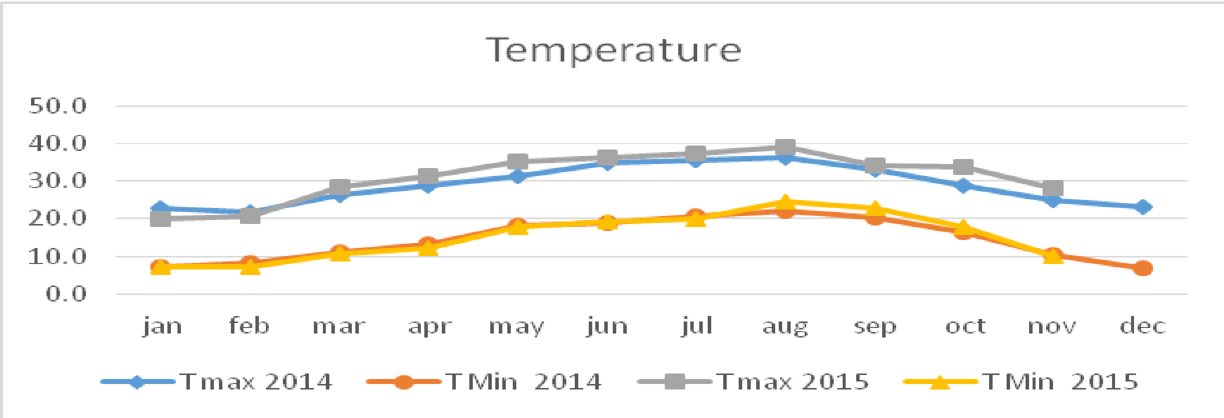

Fig. 1 The maximum and minimum temperature during two growing seasons 2014 and 2015 at Cairo-Alexandria Desert Road.

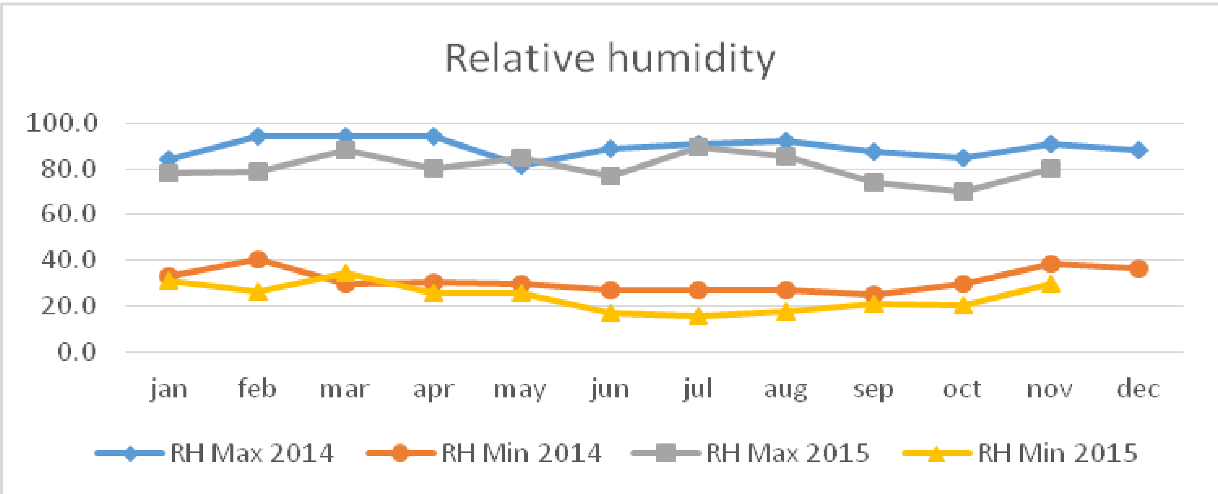

Fig. 2 The maximum and minimum relative humidity during two growing seasons 2014 and 2015 at Cairo-Alexandria Desert Road.

Soil and water properties

The experimental site is dominated by sandy Loamy texture. Some physical and chemical soil properties are shown in tables 1 and 2, respectively. The chemical composition of the irrigation water is shown in table 3.

Table (1): The physical properties of the soil experiment analyzed before treatment

Parameters	Soil depth(0-30 cm)
Sand (%)	84.5
Silt (%)	8.50
Clay (%)	7.00
Texture class	Sand Loamy
Bulk density (g cm^{-3})	1.49
Real density (g cm^{-3})	2.51
Total porosity (%)	40.6
Field Capacity (FC)	20.9
Wilting Point (WP)	9.55
Available Water (AW)	11.4
Water Holding Capacity (WHC)	29.4

Table (2): The chemical properties of the soil experiment analyzed before treatment

Parameters	Soil depth (0-30 cm)
OM (%)	0.98
pH (1:2.5)	7.63
ECe, (dS m^{-1})	3.10
Soluble cations, (meq. L^{-1})	
Ca^{++}	9.00
Mg^{++}	8.00
Na^{+}	12.9
K^{+}	1.10
Soluble anions, (meq. L^{-1})	
CO_3^{--}	0.00
HCO_3^{--}	10.5
Cl^{-}	18.0
SO_4^{--}	2.50
SAR	4.42
ESP (%)	4.99

Table (3): The chemical composition of the irrigation water samples from the experimental area

pH	ECe dS /m (1:5)	Soluble ions (me/ L)								SAR
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	
7.68	4.4	10	8	27.1	0.34	0	2.4	32.5	10.6	9.03

Estimation of Irrigation requirements for olive tree

The Estimated crop irrigation requirement, is calculated by multiplying the reference crop evapotranspiration, ETo, by a crop coefficient, Kc according to FAO, the same methodology was adopted by many studies (Allen *et al*., 1998 and Gafar, 2009).

IR = Kc * ETo * LF * IE * R* Area (Feddan)/1000

Where:

IR = Irrigation requirement (m^3/feddan).

Kc = Crop coefficient [0.45-0.85] according to (Allen *et al*., 1998 and Goldhamer *et al*., 1994).

ETo = Reference Crop Evapotranspiration (mm/day).

LF = Leaching Fraction (assumed 20% of irrigation water).

IE = Irrigation efficiency of the irrigation system in the field (assumed 90% of the total applied).

R = Reduction factor (60-70 % cover in this study)

Area = the irrigated area (one feddan = 4200 m^2).

1000 = to convert from liter to cubic meter.

Water use efficiency (WUE)

The water use efficiency (WUE) was calculated according to FAO (1982) as follows: The ratio of crop yield (y) to the total amount of irrigation water use in the field for the growth season (IR).

WUE (Kg/m3) = Y(kg) / IR (m3)

Measurements

At the end of each growing season during first week of august the following characteristics were measured:

Shoot characteristics

In each season of the study five shoots (one year old) were randomly chosen at each direction on each selected tree for the assessments, average shoots length (cm), number of leaves per shot was measured during two seasons.

Leaf characteristics, as leaf fresh weight and leaf area (cm^2) were measured according to (Ahmed and Morsy, 1999) using the following equilibration

Leaf area (cm^2) =0.53(length ×width) +1.66

Flowering parameters

Length of Inflorescence: Inflorescences length in cm was estimated as average of 20 inflorescences per tree.

Flowering density

Forty flowering shoots (10 shoots/direction) were chosen per tree, every two week from April till the end of early May (Number of inflorescences/meter). Density was calculated using the following formula:

Flowering density = (number of inflorescences×100)/ (Av. shoot length (cm)).

Yield

At the stage of green maturity fruits from each tree were harvested and weighed. A representing sample of 100 fruits were taken for assessment from each treatment.

Fruit Quality

Thirty fruit per each tree were randomly selected and used to determine the fruit quality measurements:

Fruit length (cm), Fruit diameter (cm), Fruit weight and Fresh weight (gm).

Fruit oil content (%)

It was determined by extracting the oil from the fruits, which were dried at 105^0C by means of Soxhlat fall extraction apparatus, using petroleum ether at 60-80^0 boiling points as described by the AOAC (1975).The stones were taken from the selected fruits to determine the stone weight (gm).

Leaf mineral content

At the first week of August in both seasons, 50 mature leaf samples, from previously tagged non-fruiting shoots on each replicate, were taken from the upper third of shoot top as recommended by (Piper, 1950)

Sample of 200 gm. of fresh leaves were cleaned and washed several times, with tap water. Samples were air dried and put in an electrical furnace at 70^oC to reach a constant weight and finally ground to be used for preparing the wet digested solution (Piper, 1950) which should be ready for macro nutrient analyses which were calculated as percentage of dry weight.

Mineral content

The total nitrogen was determined by modified micro-Keyldahl method as described by (Pregl, 1945). The Phosphorus content was determined colorimetrically according to the method described by Murphy and Riely (1962). The Potassium content was determined by flame photometer (Brown and Lilleland, 1946).

The experimental designed

The experiment was designed in a split- split plot arrangement with three replicates. The irrigation levels treatment was in the main plots, irrigation techniques were allocated in the sub plot and olive cultivars were allocated in the sub-sub plot.

Economic evaluation

Economic evaluation was calculated according to Heady and Dillon (1961) as follows:

- Total return (L.E/fed.) = total yield (kg) × (price/Kg was Egyptian pounds 3 in 2014and Egyptian pounds 4 in 2014).
- Water cost = total water quantity × (water price /$m^3$was Egyptian pounds 0.5 and Egyptian pounds 0.6in 2014 and 2015).
- Operation cost (fertilizer, Laborers, pesticides and others) = 5500 Egyptian pounds.
- Net income = Total return–(water cost+ operation cost)

RESULTS AND DISCUSSION

The reference Evapotranspiration ETo

The ETo was calculated from climate data for both seasons to estimate the water requirement for olive tree. Data in figure 3 illustrate the results of the ETo calculations for the Cairo – Alexandria Desert Road. The highest monthly ETo in the Cairo-Alexandria Desert Road occurs during July were8.23 and 8.59 mm/day for first and second seasons, respectively, while the lowest ETo value occurs in December were2.83 and 2.80 mm/day in both seasons, respectively. The ETo at 2015 season was increased than ETo at 2014 season. These results agreed with those of (Farag and El-Taweel 2014)

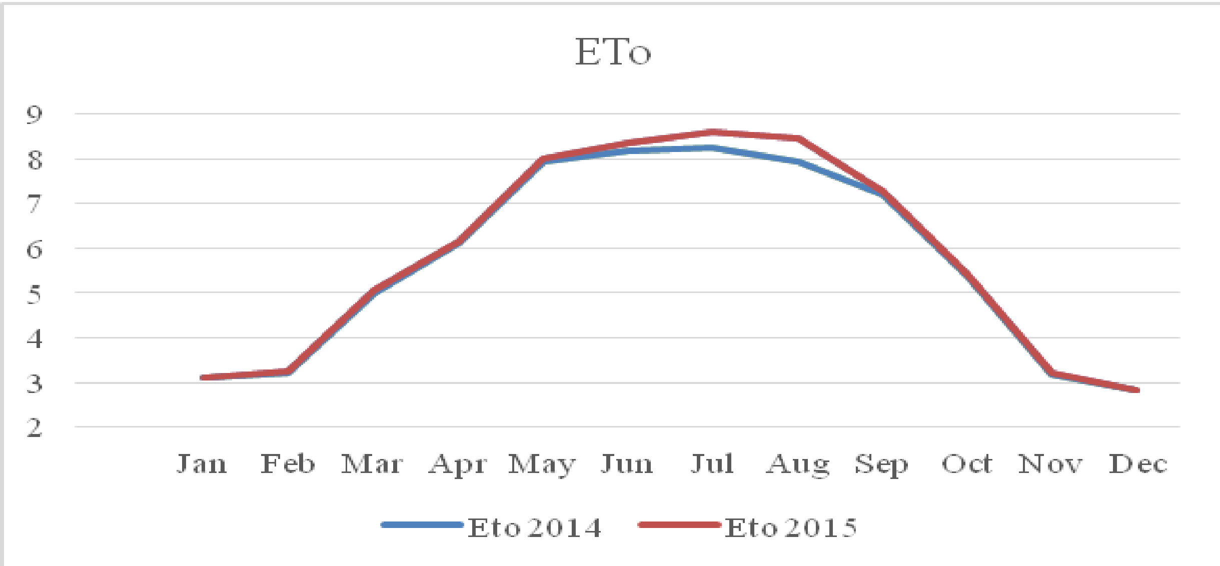

Fig (3) Reference Evapotranspiration (Eto) during two growing seasons 2014 and 2015 at Cairo-Alexandria Desert Road.

Applied and estimated water

Data in table (4) shows the applied water in different treatment compared with the estimated water. Data retrieved that the highest total applied water was 4384m^3 / Fadden, flowed by 3740 m^3 / Fadden. The lowest total applied water was 3089 m^3 / Fadden. The estimated water was increased in 2015 than 2014.

The total estimated water 3863 and 3952m^3 / Fadden for the first and second seasons, respectively, with average 3908 m^3 / Fadden. The estimate water was near to the filed applied water treatment 3740m^3 / Fadden. These results was agreed with (Farag and El-Taweel, 2014).

Table (4) Applied and estimated water during two growing seasons 2014 and 2015 to Picual and Manzanillo olive cultivars.

Month	Applied water (m^3/ feddan)in both seasons			Estimated water m^3/ feddans		
	100% (3.5h)	85% (3h)	70% (2.5h)	2014 season	2015 season	Average for both seasons
Jan.	209	178	147	112	113	113
Feb.	209	178	147	105	106	106
Mar.	313	267	221	249	251	250
Apr.	313	267	221	351	355	353
May.	522	445	368	505	516	511
Jun.	522	445	368	510	511	511
Jul.	626	534	441	572	597	585
Aug.	626	534	441	550	587	569
Sep.	313	267	221	414	418	416
Oct.	313	267	221	266	269	268
Nov.	209	178	147	126	127	127
Dec.	209	178	147	103	103	103
Total	4384	3740	3089	3863	3952	3908

Vegetative growth

Obtained results (Table5) revealed that water levels, irrigation methods and olive cultivars significantly affected vegetative growth during the two growing seasons.

Data shows that the rate of shoot length, the number of leaves and leaf area (cm^2) were affected by water level 3740 m^3/feddan (increased significantly). It was also obvious that the highest shoot length was associated with surface irrigation in the second season, while the number of leaves/ shoot was superior with surface irrigation in the both seasons, 28.06 and 29.26, respectively. Differences in leaf area were not significant in both seasons.

Concerning the affected of cultivars, Manzanillo showed the highest shoot length (20.94 and 21.95) in both seasons compared with Picual cultivar, respectively. As foe the number of leaves, Manzanillo was superior in the first season but no significantly differences was found in the second season. Concerning leaf area, Table (5) showed that the highest values were recorded with Picual trees, in both seasons.

Interaction between water levels and irrigation methods data showed an increase in shoot length, number of leaves and leaf area with 3740 m^3/ feddan combined with surface irrigation in both seasons.

Regarding the interaction between water levels and olive cultivars on vegetative growth, data showed that shoot length was significantly higher by using3740/$m^{3/}$feddan treatment with Manzanillo cultivar in both seasons. As for the number of leaves it showed the same trend during the first season but in the second season treatment 4384m^3/feddan gave the highest value when combined with Manzanillo cultivar. Picual cultivar was significantly high in leaf area measures in both seasons when irrigated with 4384m^3/feddan.

Concerning the interaction between irrigation methods and olive cultivars data showed that Manzanillo shoot length increased significantly with surface irrigation treatment during both seasons. As for Number of leaves both Manzanillo and Picual cultivars had the same trend with surface irrigation in the first season, but in the second season Picual was the superior with surface irrigation.

According to interaction between three factors, the shoot length has increased significantly with 3740/$m^{3/}$feddans, surface irrigation and Manzanillo treatment. Same trend was found in number of leaves in first seasons while, Picual gave the highest number of leaves with 3740/$m^{3/}$feddan and surface irrigation in the second season. The leaf area, Picual was the superior when trees irrigated with 3740/$m^{3/}$feddan and surface irrigation during the both seasons.

These results coincide with Magliulo *et al*., (1999). Meantime, Laz *et al*. (1999) reported that the tested cultivars showed a wide variations in response to different water levels. This may be due to different heritability of each cultivar. The increase of shoot length in both cultivars might be attribute to improved soil characteristics, water availability and the improvement of soil nutrient content (Briccoli *et al*., 2002). Also, several studies (Gucci, 2003 and Gucci *et al*., 2007) indicate that regulated deficit irrigation in olive may be suitable to improve physiological balances with a limited input supply. In addition, environmental condition play an important role in growth and productivity of olive cultivars as productivity vary according to climatic condition and environment (Lavee, 1989). Moreover, Luna, (2000), stated that this positive response to increased water supply was essentially due to vegetative growth. Whereas, Sebastiani and Michelazzo (2012), mentioned that different irrigation levels significantly modified plant physiological conditions and vegetative growth of olive cultivars.

Table (5): Effect of applied water quantities, to two Olive cultivars, on shoot length (cm), no. of leaves/shoot and leaf area (cm^2) during 2014 and 2015 seasons.

Treatments		Shoot length (cm)			No. of leaves/shoot			Leaf area (cm^2)		
I.L.	I.M.	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)
		1st season								
4384m^3 (100%)	In	17.6cd	20.8b	19.2C	28.6bcd	31ab	29.1A	4.15b	3.31de	3.73B
	On	14.3e	15.2de	14.7D	14.9 f	23.4e	23.3B	4.04b	3.43cd	3.74B
Mean (A x C)		15.9D	17.9BC	16.9B	21.8D	27.3B	26.2B	4.10B	3.37D	3.73B
3740m^3 (85%)	In	20.8b	29.0a	24.9A	23.3 e	29.2abc	28.6A	4.30a	3.49c	3.90A
	On	17.5cd	22.8b	20.2BC	26.8 d	31.7a	29.3A	4.18b	3.52c	3.85A
Mean (A x C)		19.2B	25.9A	22.5A	25.2C	30.5A	28.9A	4.24A	3.50C	3.87A
3089m^3 (70%)	In	13.7e	15.4de	14.6D	22.3e	28cd	25.3B	4.12b	3.28e	3.70B
	On	20.0bc	22.4b	21.2B	23 e	27ed	24.3B	4.06b	3.39c-e	3.73B
Mean (A x C)		16.8CD	18.9B	17.9B	22.7D	27.5b	24.8B	4.09B	3.34D	3.71B
Mean (C)		17.3B	20.9A	Mean (B)	27.4B	28.2A	Mean (B)	4.14A	3.40B	Mean (B)
Mean (B x C)		17.4C	21.8A	18.5A	27.4B	29.4A	27.7A	4.19A	3.36D	3.78A
		17.3C	20.1B	18.7A	21.7D	24.8C	25.7B	4.10B	3.45C	3.77A
		2nd season								
4384m^3 (100%)	In	20.2cd	24.3b	22.3B	31.7bcd	34.1ab	29.5A	4.17b	3.50cd	3.83BC
	On	16.2g	16.6fg	16.4D	16.7f	26e	23.9B	4.12b	3.53cd	3.83BC
Mean (A x C)		18.2C	20.4B	19.3B	24.2D	29.9B	26.8A	3.15B	3.51C	3.83B
3740m^3 (85%)...	In	23.7b	30.3a	27.0A	25.7e	32.3abc	30.8A	4.31a	3.55c	3.93A
	On	18.8d-f	20.7cd	19.8C	29.7d	34.8a	22.3B	4.19b	3.54c	3.86AB
Mean (A x C)		21.2B	25.5A	23.4A	27.6C	33.5A	26.6A	4.25A	3.55C	3.90A
3089m^3 (70%)	In	15.9g	17.7e-g	16.8D	24.3e	31cd	31.4A	4.22ab	3.32e	3.77C
	On	19.8c-e	2.1bc	20.9BC	25.3e	30cd	22.9B	4.12b	3.43d	3.77C
Mean (A x C)		17.8C	19.9B	18.9B	24.7D	30.5B	27.1A	4.17B	3.37D	3.77C
Mean (C)		19.1B	21.9A	Mean (B)	25.5B	31.3A	Mean (B)	3.19A	3.48B	Mean (B)
Mean (B x C)		19.9B	24.1A	22.0A	27.2C	32.4A	30.6A	4.24A	3.46C	3.85A
		18.2C	19.8B	19.0B	23.8D	30.2B	23.1B	4.14B	3.50C	3.82A

Values of specific or interaction effect followed by the same (capital or small letters) respectively are not significantly different at 5% level. I.L. (A) = Irrigation levels (on=sub-surface and in = surface), I.M. (B) = Irrigation Methods, C= olive cultivars (Picual and Manzanillo)

Flowering and fruiting

Data in Table (6) shows the irrigation level 3740 m^3/ fed increased significantly the number of total flowers, flowering density and perfect flower. The same trend was found under surface irrigation during the two growing seasons. Concerning the cultivars data reveal that, Manzanillo was the superior in number of total flowers/ inflorescence, flowering density and perfect of flowers than Picual.

Table (6) showed significantly effect in treatment irrigation level3740m^3/ fed with surface irrigation on number of total flowers, flowering density and perfect flower in both seasons.

Data show that Manzanillo cultivar has increased more significantly than Picual in both seasons with irrigated level3740/m3/fed.

Data revealed that Manzanillo achieved the highest values during the flowering density and perfect flowers with surface irrigation.

Data indicated that number of total flowers, flowering density and perfect flower has increased significantly with Manzanillo receiving 3740/$m^{3/}$fed of surface irrigation in both seasons.

These results were in agreement with those reported by Emad (2005) and Ahmed (2013). Also,

Deidda *et al.* (1990) and Inglese *et al.* (1996) mentioned that the response to prolonged water deficits has been investigated in terms of adaptive behaviour i.e. stomata functioning. In this connection, it could indicate that adding sufficient water obviously has preferred effect on plant growth, as it is well known that water plays vital role and has important function in all physiological processes of mineral absorption from the soil up to building different components inside the plant (Suryanarana and Venkateswarles, 1981).

Table (6): Effect of applied water quantities ،to two Olive cultivars ،on no. of total flowers/inflor, flowering density and Perfect flower (%) in 2014-2015 seasons.

Treatments		No. of total flowers/inflor.			Flowering density			Perfect flower (%)		
I.L.	I.M.	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)
1st season										
4384m3 (100%)	In	18.6b	12.5e	15.6B	33.1b-d	37.2ab	35.2A	47.4cd	50.1bc	48.6BC
	On	9.6g	11.5ef	10.6F	29.4c-e	33.3bc	31.4B	40.8f	43.3ef	42.1E
Mean (A x C)		14.1C	12.0D	13.1C	31.3BC	35.3A	33.3A	44.1E	46.7CD	45.4C
3740m3 (85%)	In	13.6d	22.2a	17.9A	33.9bc	41.3a	37.6A	52.6b	59.9a	56.2A
	On	11.1f	12.1e	11.6E	23.1g	27.9ef	25.5C	44.8de	48.3cd	46.6CD
Mean (A x C)		12.3D	17.2A	14.7A	28.6C	34.6A	31.6AB	48.7BC	54.1A	51.4A
3089m3 (70%)	In	12.0ef	16.1c	14.1C	24.0fg	36.8b	30.4B	43.2ef	47.6cd	45.4D
	On	12.6e	13.7d	13.1D	34.0bc	28.8de	31.4B	47.9cd	50.7bc	49.4B
Mean (A x C)		12.3D	14.9B	13.6B	29.0C	32.8AB	30.9B	45.6DE	49.2B	47.4B
Mean (C)		12.9B	14.7A	Mean (B)	29.6B	34.2A	Mean (B)	46.1B	49.9A	Mean (B)
Mean (B x C)		14.7B	16.9A	15.8A	30.4B	38.4A	34.4A	47.7B	52.5A	50.1A
		11.1D	12.5C	11.8B	28.9B	30.0B	29.4B	44.5C	47.4B	45.9B
2nd season										
4384m3 (100%).	In	11.3cd	11.2cd	11.3C	19.3bc	22.6ab	20.9AB	53.9b-d	56.8ab	55.4A
	On	7.9e	7.8e	7.9D	18.0c	20.5bc	19.3B	38.2g	49.3e	43.8C
Mean (A x C)		9.7C	9.6C	9.6C	18.7B	21.5AB	20.1A	46.1C	53.1A	49.6B
3740m3 (85%)...	In	11.3cd	18.0a	14.7A	19.7bc	25.6a	22.6A	55.1bc	59.3a	57.2A
	On	11.6cd	10.4d	11.0C	17.7c	19.2bc	18.5B	43.4f	51.4c-e	47.4B
Mean (A x C)		11.5B	14.2A	12.9A	18.7B	22.4A	20.6A	49.2B	55.4A	52.3A
3089m3 (70%).	In	11.2cd	11.2cd	11.2C	20.7bc	18.9bc	19.8AB	50.3de	35.9g	43.1C
	On	13.1b	12.1bc	12.6B	18.2bc	20.9bc	19.6B	49.8e	36.7g	43.3C
Mean (A x C)		12.2B	11.7B	11.9B	19.5B	19.9AB	19.7A	50.1B	36.3D	43.2C
Mean (C)		12.9B	14.7A	Mean (B)	18.9B	21.3A	Mean (B)	48.5A	48.3A	Mean (B)
Mean (B x C)		11.3B	13.5A	15.8A	19.9B	22.4A	21.1A	53.1A	50.7A	51.9A
		10.9B	10.1C	11.8B	18.0B	20.2AB	19.1B	43.8B	45.8B	44.8B

Values of specific or interaction effect followed by the same (capital or small) letters respectively are not significantly different at 5% level.
I.L. (A) = Irrigation levels (on=sub-surface and in = surface), I.M. (B) = Irrigation Methods, C = olive cultivars (Picual and Manzanillo)

Fruiting and yield

Effect of annually applied water quantities on Initial fruit set (%), Final fruit set (%) and Yield /tree (kg) in 2014-2015 seasons were show in table (7). Data showed that irrigation level of3740 m^3/fed gave the highest values of initial and final fruit sets(7.5 & 6.3% and 5.1 & 3.9%) and yield (25.1&9.5 kg/tree) compared to the 4384/m^3/fed level during the two growing seasons, respectively.

Data also revealed that the highest initial fruit sets (7.4 & 6.1%) were noticed when the trees were irrigated using sub-surface irrigation method in both seasons, respectively. On the other hand, trees irrigated with surface irrigation showed the highest final fruit sets (4.7 & 3.6%) and yields (26 & 9.9kg/ tree) in both seasons, respectively.

Manzanillo cultivar exhibited the highest significant values in initial & final fruit sets (7.9%& 6.4% and 5.3%&3.7%) and yield (27.8&10.6kg/tree)in both seasons, respectively.

The obtained data shows that the interaction between irrigation quantity and irrigation methods gave the highest values of initial fruit set (8.0%) when irrigating with 3089/m^3/fed combined with surface irrigation at the first season. In this concern, the initial fruit set when irrigating with the 3089/m^3/fed and sub-surface method had the superior value (6.7%) in the second season.

Table (7) also showed that Manzanillo gave highest initial &final fruit set values (8.2 & 6.9% and 5.9 & 4.2%)and highest yield (28.6 &10.9 kg/tree) when irrigated with 3740 m^3/fed.

Data indicated that, initial fruit set (%) effect on both cultivars. Manzanillo was the superior (7.9%&6.9%) with surface irrigation during both seasons respectively. Manzanillo was significantly affected fruit set (5.51&4.1) and yield (30 &11.6 kg/tree) with In-line irrigation than Picual during both seasons.

Table (7) also indicated that Manzanillo exhibited the highest values of initial fruit set when irrigated by 3740 m^3/fed with surface irrigation in the first season. In reverse direction, Manzanillo was the highest values when irrigated by 3089 m^3/fed with sub-surface in the second season.

Concerning the final fruit set (%) and yield, Manzanillo was recorded highest final fruit set (6.2 & 4.8 and 33.9 & 12.9 kg/tree), when irrigated with 3740 m3/fed with surface during both seasons respectively.

These results were in agreement with those obtained by Sebastiani *et al*. (2012). Moreover, Gucci *et al*. (2007) reported that irrigation can increase the number of fruits per tree and no differences were found between fully and 46% of the total water requirement (regulated deficit irrigation) irrigated trees. Also, Tiwari*et al*. (2003) stated that the yield per unit quantity of water used increased by increasing water deficit. Moreover, Lavee and Wonder (1991), reported that suitable water supply decreased fruit drop, possibly due to reducing competition between fruits. More recent, Fereres (1995) confirmed that maximum production is reached when the applied irrigation water close to the maximum crop water requirements, but other workers reported that irrigation and cultivars affect fruit number per plant, fruit dry weight and yield per plant (Sebastiani *et al*., 2012).

Table (7): Effect of annually applied water quantities on Initial fruit set (%), Final fruit set (%) andYield /tree (kg) in 2014-2015 seasons.

Treatments		Initial fruit set (%)			Final fruit set (%)			Yield /tree (kg)		
I.L.	I.M.	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)
		1st season								
4384m³ (100%)	In	7.8e	7.9bc	7.3C	3.5e	5.8b	4.7C	22.1f	31.7b	26.9B
	On	6.1f	7.5cd	6.8D	2.9g	4.0d	3.5E	2.9g	21.7fg	12.3F
Mean (A x C)		6.4D	7.7B	7.1B	3.2F	4.9C	4.1C	12.5E	26.7B	19.6C
3740m³ (85%)	In	6.8e	8.4a	7.6B	4.7c	6.2a	5.4A	23.3e	33.9a	28.6A
	On	6.9e	8.1ab	7.5BC	4.0d	5.6b	4.8BC	19.7h	23.3e	21.5E
Mean (A x C)		6.8C	8.2A	7.5A	4.3D	5.9A	5.1A	21.5C	28.6A	25.1A
3089m³ (70%)	In	5.6g	7.3d	6.5E	3.2f	4.5c	3.9D	18.8i	25.9d	22.3D
	On	7.8bc	8.3a	8.0A	4.1d	5.7b	4.9B	21.1g	30.3c	25.7C
Mean (A x C)		6.7C	7.8B	7.2B	3.8E	5.1B	4.4B	20 D	28.1A	24B
Mean (C)		6.7B	7.9A	Mean (B)	3.8B	5.3A	Mean (B)	18B	27.8A	Mean (B)
Mean (B x C)		6.4C	7.8A	7.1B	3.8C	5.51A	4.7A	21.4C	30A	26A
		6.9B	7.9A	7.4A	3.7C	4.1B	4.4B	14.6D	25.1B	19.8B
		2nd season								
4384m³ (100%)	In	5.6f	6.5cd	6.1B	2.87e	4.2b	3.6B	8.4f	12b	10.2B
	On	4.3h	6.5cd	5.4C	2.83e	3.3d	3.1D	1.1j	6.2fg	4.6F
Mean (A x C)		4.9E	6.5B	5.7B	2.85F	3.8B	3.3B	4.8E	10.1B	7.5C
3740m³ (85%)	In	6.1de	7.0ab	6.6A	3.7c	4.8a	4.2A	9.8e	12.9a	10.9A
	On	5.4f	6.8bc	6.1B	3.3d	3.7c	3.5B	7.4h	8.6e	8.2E
Mean (A x C)		5.8C	6.9A	6.3A	3.5C	4.2A	3.9A	8.2C	10.9A	9.5A
3089m³ (70%)	In	4.8g	4.3h	4.6D	2.7e	3.3d	2.9D	7.1i	9.8d	8.5D
	On	6.1e	7.4a	6.7A	3.8c	2.8e	3.3C	8 g	11.5c	9.8C
Mean (A x C)		5.4D	5.9C	5.6B	3.3D	3.1E	3.2C	7.6D	10.7A	9.1B
Mean (C)		5.4B	6.4A	Mean (B)	3.2B	3.7A	Mean (B)	6.8B	10.6A	Mean (B)
Mean (B x C)		5.5C	5.9B	5.7B	3.1C	4.1A	3.6A	8.1C	11.6A	9.9A
		5.3D	6.9A	6.1A	3.3B	3.3B	3.3B	5.5D	9.5B	7.5B

Values of specific or interaction effect followed by the same (capital or small) letters respectively are not significantly different at 5% level.
I.L.(A) = Irrigation levels (on=sub-surface and in = surface), I.M.(B) = Irrigation Methods, C= olive cultivars (Picual and Manzanillo)

Fruit Quality

The effect of irrigation levels on olive trees is shown in Table (8).The 4384/m3/fed and3740 m3/fed irrigation water levels for olive cultivars showed highest values of fruit, seed and flesh weight during both seasons, respectively.

Interaction between with irrigation methods and irrigation levels the treatment3089m3/fed from in-line irrigation recorded highest values of fruit weight and seed weight in the first and second seasons respectively.

On other hand, both 4384/m^3/fed and 3089 m3/fed in- line irrigation in the second one showed the best values as irrigation with 100% and 85% had the same trend in the first season. As for seed and flesh weight showed the highest significant values as irrigated with3089 m3/fed inline irrigation in the second season, respectively.

As related to the interaction effect of the two factors: level rates and both Picual and Manzanillo under study, Manzanillo was superior when irrigated with 4384m^3/fed and 3740 m^3/fed levels during both seasons.

Considering the interaction effect among irrigation method and cultivar, fruit& seed and flesh weight of Manzanillo cv. responded significantly to the level of 3740m3/fed irrigation.

In regard to the interaction effects of three factors: irrigation level, irrigation methods and cultivars of fruit weight, Manzanillo showed the highest significant values as irrigated with 4384m^3/feddan In-line and On-line irrigation in the first season. In contrast, Manzanillo achieved the highest values when irrigated with 3740 m^3/feddan In-line irrigation in the second season.

Fruit oil content presented in table (8) and figure (4) shown that there was differences for fruit oil content among the treatments in both seasons. The fruit oil content was highest in In-line (surface irrigation) in both seasons. The maximum values of fruit oil content found under the 3089 /m3/fed compared to other treatments in both seasons of study. The mean values of fruit oil content gradually increased with decreasing water quantity.

The Picual cultivar gave the highest Fruit oil content than Manzanillo in both seasons. The highest fruit oil content was found with3089 /m3/fedand in-line (surface irrigation) combined with Picual cultivar.

These results in general are in agreement with those reported by Inglese *et al.* (1996) and Alegre *et al.*(2002).Also, Soil water availability affects both fruit quality and oil yield of olive trees and irrigation increases fruit size and oil content. Gucci and Rapapoport (2014) indicated that soil water availability have an effect on both fruit quality and oil yield of olive trees. In addition to that, Andria and Morelli (2002) found that production and fresh quality were positively affected by irrigation level. Also, the time and amount of irrigation have been reported to influence yield, fruit size and mesocarp weight (Caruso*et al.*, 2011). In the olive fruit the endocarop represents about 33% of fruit fresh weight that, depending on cultivar and water availability (Gucci *et al*., 2009). The mesocarp and endocarp (both dry and fresh) were significantly higher in fruits of the fully-irrigated trees than other treatments. Caruso*et al.* (2011).Lavee *et al.* (2007) reported that increase water availability in the soil increase final fruit size of olive trees. Moreover, Yield and yield components were positively affected by irrigation (Patumi *et al.*, 2002). So, water deficit reduced fruit growth (Inglese *et al.*, 1996). Furthermore, percent oil content in the pericarp usually decreases under fully irrigated conditions because of a propor-tionally larger increase of the water content of the fruit (Lavee and Wonder, 1991). Rinaldi *et al.* (2011) added similar results. Caruso et al., (2011) confirmed that the 17 %decrease in oil yield occurred when subjecting young olive trees to about 50% deficit irrigation during the summer months. As for moderate deficit irrigation did not decrease the amount of oil produced per tree (Gucci and Rapapoport 2014).In an early work of Barone *et al.* (1994) pointed thet the oil accumulation does not only rely on genetic specificity but rather on environmental conditions, particularly water availability and fruit yield. While others have suggested, the different irrigation treatments had no significant impact on olive fruit yield per tree and olive oil quality in any of the seasons Puetas and Trentacoste (2011).

These findings greatly confirmed the results of previous studies carried out by Lavee and Wonder (1991), Rinaldi, *et al.* (2011). Iniesta *et al.*(2009) and Gucci and Rapapoport (2014) confirmed that deficit irrigation caused a higher reduction in fresh fruit yield than oil yield due to a higher oil concentration in deficit irrigated trees, but other workers revealed that, full irrigation is an important for oil production (Lavee *et al.*,2007). Indeed a marked effect of water deficit on oil quantity has been reported for young olive trees characterized by reduced root volume (Dettori *et al.*, 1990).

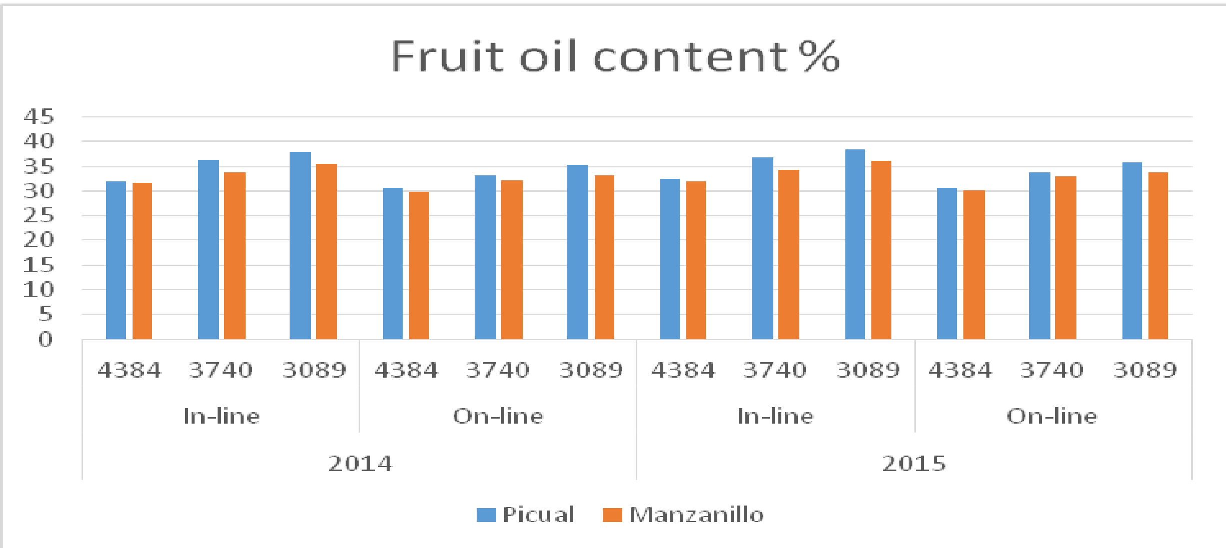

Fig (4) Olive fruit oil contents (%) during two growing seasons 2014 and 2015 at Cairo-Alexandria desert road.

Leaf minerals content (%)

Nitrogen

The specific and interaction effect of three irrigation levels (100, 85 and 70%); and water sources (in and on) on NPK content (%) in both olive cv. are presented in Table(9).The effect of irrigation levels on olive trees is shown in Table (9). Irrigation with 3089m3/feddan level showed the highest N content of olive cvs. during both seasons. As for irrigation method, in –line soil increased significantly during the two growing seasons. As for cultivars, Manzanillo cv. gave the highest values in the first and second seasons.

Concerning the interaction effect of three water levels and irrigation methods showed in Table (9).Trees receiving3089m^3/feddan level with on- line method showed the highest significant value of N leaf content in the first season. While, in the second one the highest values were obtained with 3089m^3/feddan level in and on- line method .With regard to Manzanillo olive trees irrigated with 3089m3/feddan level has the highest N content during both seasons. As referring to irrigation methods, Manzanillo olive trees irrigated with in- line method showed higher N content in the first and second seasons. Regarding to the three investigated factors, Manzanillo cv. was the most significant in N content when irrigated with 3089 m^3/ feddan level on soil method in the first season. In the contrary, during the second season Picual olive trees as irrigated with3089m3/feddan in soil method gave the highest value of N content. These results go in line with Moustafa (2002), who reported that leaf N. content was decreased as amount of applied water were increased. Karam *et al.* (2002) reported that the highest nitrogen uptake was observed in lettuce plants of the well – irrigated treatment and it decreased with increasing water stress level. Patumi *et al.* (1999) revealed that the olive cv. of leaf N content was decreased by increasing available soil water.

Phosphorus

Referring to the specific effect of different irrigation levels on P content of olive cvs. The irrigation with 4384 m^3/feddan had the highest significant value of P content during both seasons. As related to irrigation method, irrigated with in-line had the highest P value in the first and second seasons. Picual and Manzanillo had the highest values of P content in the first season. Whereas, Picual was the highest in the second season.

Regarding the interaction effect of three water levels and irrigation methods showed in Table (9).Trees receiving4384m^3/feddan level with in- line method showed the highest significant value of P leaf content in the first season. While, in the second one the highest values were obtained with 4384m^3/feddan level on- line method .According to irrigation method and olive cvs, Manzanillo had the highest values with 4384m^3/feddan level of N content in the first season. Meantime in the second season Picual cv. irrigated with4384m^3/feddan level gave the highest values of P. As referring to irrigation methods and olive cvs. Manzanillo olive trees irrigated with in-line method showed higher p content in the first On the contrary Picual cv. irrigated on-line soil was scored the highest significant values in the second season. Regarding to the three investigated factors, Manzanillo cv. was the most significant in P content when irrigated with 4384m3/feddan level in-line soil method in the first season. In the contrary, during the second season Picual olive trees as irrigated 4384m3/feddan level on-line soil method gave the highest value of Content.

These results go in line with Emtithal *et al.* (2002), Emad (2005) and Patumi *et al.* (1999) reported that leaf mineral content of P and K have increased by increasing available soil water, but other workers reported that the reduction in soil irrigation rate caused significant decrease in concentration of leaf P and K content (Abd El-Messeih and El-Gendy,2004).

Potassium

Table (9). Shows the specific and interaction effect of three water levels, two methods of water and two olive cultivars on potassium (K) content (%).

Irrigation with 4384m^3/feddan showed the highest K content in the first and second seasons. As related to methods irrigation, the irrigated in- line and on-line take the same trend of 4384m^3/feddan level in the first season, while in the second one the highest value of 4384m^3/feddan level was in-line soil method. As related to cultivar effect, Manzanillo gave the highest values in the first and second seasons.

Table (9). Shows the interaction effect of three water levels and two line methods on Potassium (K) content (%).

Irrigation with 4384m^3/fed in- line method gave the highest values during both seasons. Concerning the interaction effect of three water levels and both olive cultivars, Manzanillo was significantly increased in K content with 4384m3/fed during the two growing seasons. As for methods irrigation and cultivars, Manzanillo, irrigated with on-line soil method, gave the highest values of K in the first season. Whereas, in the second season Picual irrigated with in-line soil achieved the highest K values percentage. As refer to the three investigated factors, the irrigation of Manzanillo olive cv. with 4384 m^3/fed in-line and on-line soil methods surpassed other treatments of K. in the first season. While in the second season, Manzanillo trees irrigated with 4384m3/fed on-line method had the highest values of K.

The present data are in line with many works like Laz *et al.* (1999), Moustafa (2002) and Emad (2005). Ayman (2015) reported that, as the level of irrigation supply increased a general subsequent increase was observed in leaf mineral percentage. Other workers reported that potassium availability to roots usually increased with water shortage; (Marschner, 1986) and Nakajim *et al.* (2004). Also, Emtithal *et al.* (2002), found that leaf K (%) significantly reduced as water quantity has decreased.

Table(8): Effect of annually applied water quantities on Fruit weight (g), Seed weight (g), Flesh weight (g) and Fruit oil content (%)in 2014-2015 seasons.

Treatments		Fruit weight (g)			Seed weight (g)			Flesh weight (g)			Fruit oil content (%)		
I.L.	I.M.	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)
		1st season											
$4384m^3$	In	3.8bc	4.8a	4.3AB	0.68bc	0.86a	0.77AB	3.1bc	3.9a	3.5AB	32e	31.5ef	31.8D
100%	On	4.3ab	4.8a	4.5A	0.77ab	0.86a	0.81A	3.5ab	3.9a	3.6A	30.5fg	29.8g	30.2E
Mean (AxC)		4B	4.8A	4.4A	0.72B	0.86A	0.79A	3.3B	3.9A	3.6A	31.3D	30.7D	31C
$3740m^3$	In	4.3ab	4.8a	4.5A	0.77ab	0.87a	0.82A	3.4ab	3.9a	3.7A	36.3b	33.6d	35B
85%	On	3.8bc	4.7a	4.2AB	0.68bc	0.84a	0.76AB	3.1bc	3.8a	3.5AB	32.5de	31.4ef	32D
Mean (AxC)		4B	4.8A	4.4A	0.72B	0.86A	0.79A	3.3B	3.9A	3.6A	34.4B	32.5C	33.5B
$3089m^3$	In	4.6a	4.6a	4.6A	0.83a	0.83a	0.83A	3.7a	3.7a	3.7A	37.8a	35.5bc	36.7A
70%	On	3.3c	4.4a	3.8B	0.59c	0.80a	0.69B	2.6c	3.6a	3.1B	35.2c	33.2d	35.2C
Mean (AxC)		3.9B	4.5A	4.2B	0.71B	0.81A	0.76B	3.2B	3.7A	3.5B	36.5A	34.4B	35.4A
Mean (C)		4.0B	4.7A	Mean (B)	0.72B	0.84A	Mean (B)	3.3B	3.8A	Mean (B)	34.1A	32.5B	Mean (B)
Mean (Bx C)		4.2B	4.7A	4.5A	0.76B	0.85A	0.80A	3.4B	3.9A	3.7A	35.4A	33.5B	34.5A
		3.8C	4.6AB	4.2A	0.68B	0.83AB	0.75A	3.1C	3.8AB	3.4A	32.7C	31.5D	32.1B
		2nd season											
$4384m^3$	In	4.2bc	5.3a	4.7AB	0.75bc	0.95a	0.85AB	3.4bc	4.3a	3.9AB	32.4e	32e	32.2D
100%	On	4.7ab	5.3a	5A	0.85ab	0.95a	0.9A	3.9ab	4.3a	4.1A	30.7f	30f	30.4E
Mean (AxC)		4.4B	5.3A	4.9A	0.80B	0.95A	0.88A	3.6B	4.3A	4A	31.6D	31D	31.3C
$3740m^3$	In	4.7ab	5.4a	5.0A	0.85ab	0.97a	0.91A	3.9ab	4.4a	4.1A	36.8b	34.1d	35.5B
85%	On	4.2bc	5.2a	4.7AB	0.75bc	0.93a	0.84AB	3.4bc	4.3a	3.8AB	33de	31.9e	32.4D
Mean (AxC)		4.4B	5.3A	4.9A	0.80B	0.095A	0.88A	3.6B	4.3A	4A	34.9B	33C	34B
$3089m^3$	In	5.1a	5.1a	5.1A	0.92a	0.92a	0.92A	4.2a	4.2a	4.2A	38.3a	36bc	37.2A
70%	On	3.6c	4.9a	4.3B	0.65c	0.88a	0.77B	3c	4a	3.5B	35.7c	33.6d	34.7C
Mean (AxC)		4.4B	5A	4.7B	0.78B	0.90A	0.84B	3.6B	4.1A	3.8B	37A	34.8B	35.9A
Mean (C)		4.4B	5.2A	Mean (B)	0.79B	0.93A	Mean (B)	3.6B	4.3A	Mean (B)	34.5A	32.9B	Mean (B)
Mean (Bx C)		4.7B	5.2A	5A	0.84B	0.94A	0.89A	3.8B	4.3A	4.1A	35.9A	34B	34.9A
		4.2C	5.1AB	4.7A	0.75C	0.92AB	0.84A	3.4C	4.2AB	3.8A	33.2C	31.8D	32.5B

Values of specific or interaction effect followed by the same (capital or small) letters respectively are not significantly different at 5% level.
I.L.(A) = Irrigation levels (on and in), I.M.(B) = Irrigation Methods, C= olive cultivars (Picual and Manzanillo).

Table(9): Effect of annually applied water quantities on Leaf minerals content i.e. leaf N content (%), leaf P content (%)and leaf K content in 2014-2015 seasons.

Treatments		N %			P %			K %		
I.L.	I.M.	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)	Picual	Manzanillo	Mean (A x B)
		1st season								
$4384m^3$	In soil	1.30g	1.40c	1.35D	0.51c	0.72a	0.62A	0.46c	0.55a	0.50A
(100%)	On soil	1.36de	1.34f	1.35D	0.66b	0.46d	0.56B	0.43d	0.54a	0.48B
Mean (A x C)		1.34E	1.37C	1.35C	0.58A	0.59A	0.59A	0.45C	0.45A	0.50A
$3740m^3$	In soil	1.39c	1.36e	1.38C	0.47d	0.38e	0.42C	0.49b	0.36f	0.43D
(85%).	On soil	1.38cd	1.36ef	1.37C	0.31g	0.38e	0.35D	0.46c	0.43d	0.45C
Mean (A x C)		1.39B	1.36CD	1.38B	0.39B	0.38BC	0.38B	0.74B	0.40DE	0.44B
$3089m^3$	In soil	1.35ef	1.46b	1.40B	0.36ef	0.35ef	0.36D	0.39e	0.39e	0.40E
(70%)	On soil	1.35ef	1.49a	1.42A	0.36ef	0.34f	0.35D	0.37ef	0.44d	0.39E
Mean (A x C)		1.35D	1.47A	1.42A	0.36CD	0.35D	0.36C	0.38E	0.42D	0.40C
Mean (C)		1.36B	1.40A	Mean (B)	0.45A	0.44A	Mean (B)	0.43B	0.46A	Mean (B)
Mean (B x C)		1.35D	1.41A	1.38A	0.45B	0.48A	0.47A	0.45B	0.43C	0.45A
		1.37C	1.39B	1.38A	0.44B	0.39C	0.42B	0.43C	0.47A	0.44A
		2nd season								
$4384m^3$	In soil	1.13h	1.91a	1.52D	0.53c	0.47d	0.50C	0.61b	0.62b	0.62A
(100%).	On soil	1.57g	1.91a	1.74B	0.73a	0.51c	0.62A	0.51e	0.66a	0.59B
Mean (A x B)		1.35D	1.91A	1.63B	0.63A	0.49C	0.56A	0.57B	0.64A	0.60A
$3740m^3$	In soil	1.66e	1.54g	1.60C	0.51c	0.51c	0.51C	0.55c	0.55c	0.55BC
(85%)..	On soil	1.62f	1.01i	1.31E	0.53c	0.43e	0.48D	0.46d	0.52e	0.49DE
Mean (A x B)		1.64C	1.27E	1.45C	0.52B	0.47D	0.49B	0.50C	0.53DE	0.51B
$3089m^3$	In soil	1.93a	1.76d	1.84A	0.33g	0.40f	0.37E	0.57c	0.44fg	0.51CD
(70%)	On soil	1.87b	1.81c	1.84A	0.57b	0.56b	0.57B	0.43f	0.45g	0.44E
Mean (A x B)		1.90A	1.79B	1.45A	0.48CD	0.45E	0.47C	0.50E	0.45F	0.48B
Mean (C)		1.63B	1.66A	Mean (B)	0.53A	0.48B	Mean (B)	0.52A	0.54A	Mean (B)
Mean (B x C)		1.57C	1.74A	1.66A	0.46C	0.61A	0.46B	0.57A	0.54B	0.56A
		1.69B	1.58C	1.63B	0.46C	0.50B	0.56A	0.47C	0.45B	0.21B

Values of specific or interaction effect followed by the same (capital or small) letters respectively are not significantly different at 5% level.

I.L.(A) = Irrigation levels (on and in), I.M.(B) = Irrigation Methods, C= olive cultivars (Picual and Manzanillo).

Water use efficiency (WUE)

Data in Figure 5shows differences for WUE among the treatments in both seasons. The WUE was highest in subsurface irrigation in both seasons. The maximum values of WUE found under the3089 /m^3/fed compared to other treatments in both seasons. The mean values of WUE gradually decreased with increasing water quantity. The Manzanillo cultivar gave the highest WUE than the Picual in both seasons. The highest WUE was found with3089 /m^3/fed with subsurface irrigation combined with Manzanillo cultivar. The same trend was found by Lmtiyaz *et al.* (2000) and Tiwari *et al.* (2003) who found that the yield per unit quantity of water used increased by increasing water deficit.

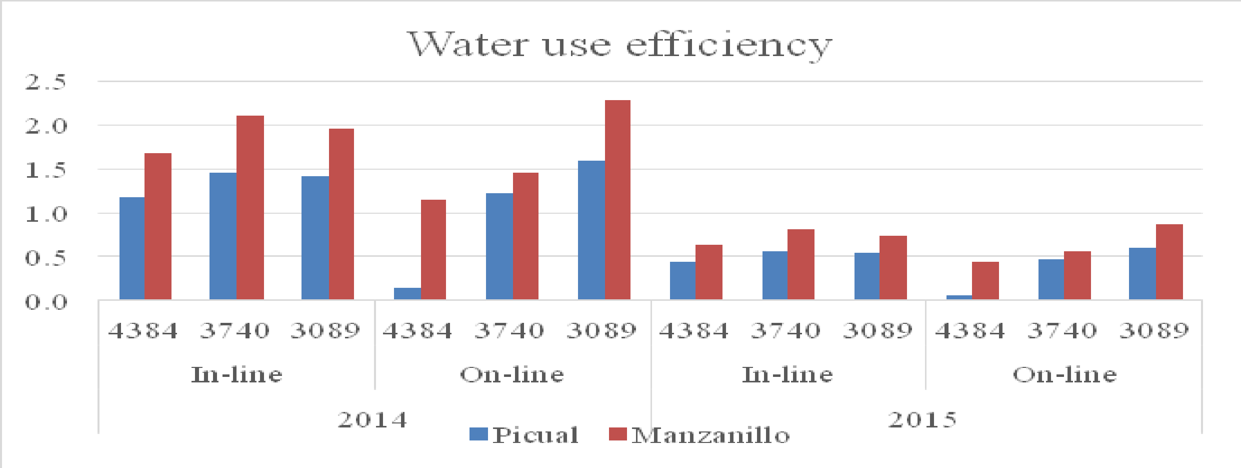

Fig (5) Water use efficiency (WUE) during two growing seasons 2014 and 2015 at Cairo-Alexandria Desert Road.

Economic study

Table (10) shows total yield of both olives cultivars, in Kg/feddan and total return in Egyptian pounds. Price/Kg was Egyptian pounds 3 in 2014 and Egyptian pounds 4 in 2015 and water price/meter was Egyptian pounds 0.50/m^3. Total operation cost included water costs plus costs of fertilizers, labors, pesticides and others.

The net income of the irrigation level 3740m3/feddan plus in-line method application on yield of Manzanillo olive trees achieved the highest net income during 2014 and 2015 seasons. It's recommend to apply this treatment to get the highest rate of economic.

Table (10) Economic evaluation of the effect of irrigation levels, methods and cultivars treatments on olive trees during 2014 and 2015.

I.L.	I.M.	Cultivars	Yield Kg/Fedaan		Yield Price (EP./ Feddan)		Water price (EP / Feddan)		Total Cost (EP)		Net Income (EP)	
			2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
4384	In	Picual	5157	1960	15471	7839	2192	2630	7692	8130	7779	-292
		Manz.	7378	2804	22135	11215	2192	2630	7692	8130	14443	3085
	On	Picual	668	254	2004	1015	2192	2630	7692	8130	-5688	-7115
		Manz.	5048	1918	15145	7673	2192	2630	7692	8130	7453	-457
3740	In	Picual	5437	2066	16310	8264	1870	2244	7370	7744	8940	520
		Manz.	7899	3002	23696	12006	1870	2244	7370	7744	16326	4262
	On	Picual	4582	1741	13747	6965	1870	2244	7370	7744	6377	-779
		Manz.	5429	2063	16287	8252	1870	2244	7370	7744	8917	508
3089	In	Picual	4373	1662	13118	6646	1545	1853	7045	7353	6073	-707
		Manz.	6035	2293	18104	9173	1545	1853	7045	7353	11060	1819
	On	Picual	4924	1871	14772	7485	1545	1853	7045	7353	7728	131
		Manz.	7068	2686	21203	10743	1545	1853	7045	7353	14159	3389

I.L. (m^3/fed) = irrigation levels (on and in), I.M. = Irrigation Methods

CONCLUSION

The results of the experiments indicated that irrigation level 3740 m^3/feddan was the optimum water requirement for olive trees at Cairo-Alexandria desert road of Egypt. The In-line (surface irrigation method) was better than on-line (sub-surface irrigation method). The Picual cultivar has the highest oil contents while fruit yield was the highest for Manzanillo cultivar. The WUE gradually decreased with increasing water quantity.

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تأثير كميات مياة الري على نمو وجودة ثمار أشجار الزيتون تحت ظروف الأراضي المستصلحة الجديدة

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أجريت هذه التجربة خلال موسمي ٢٠١٤ و ٢٠١٥ في مزرعة خاصة على بعد ٦٤ كم من طريق القاهرة أسكندرية الصحراوي لدراسة تأثير مستويات ري مختلفة وكانت مستويات الري (١٠٠%= ٤٣٨٤ م^{3}/فدان،٨٥%=٣٧٤٠ م^{3}/فدان،٧٥ %= ٣٠٨٩ م^{3}/فدان من كمية ري المزرعة) ونظامين ري:فوق سطح التربة وتحت سطح التربة. صممت التجربة على قطع منشقة مرتين في ثلاثة مكررات لدراسة اثر المعاملات على نمو ومحصول شجرة الزيتون و لصنفين البيكوال و المنزانللو.

أشارت النتائج المتحصل عليها أن استخدام الري بمستوى ٣٧٤٠م^{3}/فدان والمتوافق مع تقدير كمية الرى بالطريقة الحسابية أعطى أعلى نمو ومحصول بالمقارنة إلى بقية المعاملات الأخرى وبالنسبة لطرق الري: سجل نظام فوق سطح التربة أعلى القيم للمحصول والزيت خلال موسمي الدراسة وأظهر صنف البيكوال أعلى محتوى زيت بينما قل المحصول عن صنف المنزانللو، كذلك أظهر التفاعل بين مستويات ونظم الري وصنفي الدراسة ، أن معاملة ٣٧٤٠م٣/فدان وصنف المنزانللو أنها أفضل معاملة وكانت كفاءة الري في علاقة عكسية مع مستويات الري أي كلما زاد كمية المياه المضافة قلة كفاءة استخدام المياه.

تحت ظروف هذه الدراسة والظروف المماثلة يمكن التوصية بأن الري ب٣٧٤٠م^{3}/فدان هو مستوى الري الأفضل لشجرة الزيتون مع استخدام نظام الري فوق سطح التربة حيث حقق صنف المنزانللو من خلال الدراسة الاقتصادية أعلى صافى ربح.

الكلمات الدالة : أصناف الزيتون – طريقة الرى – مستويات الرى