World Journal of Agricultural Sciences 17 (3): 202-221, 2021
ISSN 1817-3047

DOI: 10.5829/idosi.wjas.2021.202.221

Effect of Kaolin Spraying and Different Irrigation Levels on Flowering, Fruiting and Productivity of "Picual" Olive Cv.

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Abstrac: There are many areas affected with productivity reduction and it is the problem of planted olives areas in Egypt. This habit causes severe loss for olive growers income expressed in disturbances in yearly income of the orchard and poor fruit quality.because climate changes and high temperatures (over 30°C) during blooming period induced reduction of fruit set in olive cvs. This work was conducted to investigate the effect of irrigation daily by 80, 100 and 120 % ETc beside the control for a sustainable balance between water saving spraying of and foliar application of Kaolin 5 % in March, April, May and June, tree vigour and oil production based on knowledge on the sensitivity of the olive tree to water stress at different phenological stages, the effect of this on blooming, fruiting aspects and chercteristics, fruit chemical contents of "Picual" olive cv. throughout two successive seasons (2017 and 2018 seasons). These trees were 17-years-old and planted at 6 x 6 m. apart in a sandy soil in a private orchard at Al-Khatatba, Minufiya Governorate. The study aims to improve flowering, productivity and fruit quality of olive trees. The Perfect flowers (%), irrigation daily by 80 % ETc and Kaolin in 1st March, April, May and June gave the highest significant values compared to other treatments and the control, respectively. Irrigation daily by 80% ETc and Kaolin spraying, increased significantly number of fruit set /m, number of remained fruit (m), improving fruit weight and yield (Kg/tree) of Picual cv. in both seasons. Data indicated that, the irrigation daily by 80% ETc and Kaolin sprays gave the highest significant values in fruit length and width of Picual cv. during the two growing seasons. Although fruit weight (g) of Picual cv. was affected significantly by irrigation daily by 80% and foliar sprays of Kaolin in both seasons. This research can recommend irrigation daily by 80 % ETc (2934-3079 m^3/fed/year) and foliar application of Kaolin in 1st March, April, May and June for improving perfect flowers (%), set fruit/m, number of remained (m), fruit weight, yield (kg/tree), gave the lowest fruit drop (%) and gave the highest significant values in fruit oil (%) during both seasons, reducing economic losses and thus increasing the income for growers.

Key words: Olive · Kaolin · Blooming · Fruit set /m · Fruit drop · Fruit moisture % · Net return

INTRODUCTION

Olive tree (*Olea europaea* L.) belongs to the family Oleaceae. It can thrive and produce in the new reclaimed areas where other crops can't grow. Besides, nutritional importance of olive fruits, either as table olive or for olive oil production. Olive crop is considered a strategic significant crop in reclaimed lands that achieve highly expensive either in local or in foreign markets [1]. Olive cultivation plays an important role in the economy of many countries; comparatively it resists drought and salinity conditions largely. In addition, it increases the land values where the soil is unsuitable for other crops [2]. In addition, olive offers a great economic potential. Olives, also have good nutritional and medical uses table fruits or for oil production. Olive production plays an important role in the economy of many Mediterranean countries. Hence, olive trees areas increased rapidly in Egypt and the last statistics of the cited that the total grown olive area reached (247742 feddans) and the fruiting area is (202985 feddans) produced (882029, 1 tons) [3].

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Climate change is undoubtedly the most imminent environmental issue the world is facing today. The rise in climate temperature will have certain major effects on ecosystems, wildlife, food chains and eventually human life [4]. Climate change alters both average and extreme temperatures and precipitation patterns, which in turn influence crop yields, pest and weed ranges and introduction and the length of the growing season [5]. Temperatures are often higher than optimal in ornamental production systems. This situation may stress plants, causing a reduction of quality and yield of ornamental crops [6].

Reflective materials can be applied as a leaf or fruit particle film coating to reduce solar heat stress, especially in areas with hot or sunny weather for a substantial part of the year. Such coatings can reduce heat stress, the extent of solar-injured fruit and water stress and are involved in pest control and the suppression of disease incidence [7]. Some of the reflective materials that may be used as leaf coating material include kaolin.

Kaolin is a naturally occurring mineral (a clay), main constituent is kaolinite, with the formula $Al_4Si_4O_{10}$ (OH) 8 with the following theoretical composition SiO_2 = 46.5%, Al_2O_3 = 39.5% and H_2O =14% [8]. Kaolin has been tested in different horticultural crops and its response has been heterogeneous [9]. Kaolin showed a reduction on leaf temperature in apple trees and improved light-saturated CO_2 assimilation rate (Amax) and stomatal conductance (gs) in citrus at midday [10, 11]. However, kaolin has no effect on gas exchange parameters in pepper and did not suffice to mitigate the adverse effects of heat and water stress on photo- synthesis in almond and walnut and enhanced water loss from fruit in tomato [12, 9, 13]. Brito *et al.*[14] cleared that, the olive orchards, rainfed managed, are threatened by the current and predicted adverse environmental conditions, which change the yield and quality of olive products, largely known for its benefits to human health. To mitigate these problems, it is highly recommended to perform some adjustments in agronomic practices, such as the use of foliar sprays that cloud help the trees to cope with climate change. During two consecutive years, olive trees were pre-harvest sprayed with kaolin (KL) and salicylic acid (SA) to attenuate the adverse effects of summer stress. Olive yield was increased by 97% and 72% with KL and SA, respectively.

But, there are many areas affected with productivity reduction (according to the latest statistics of Ministry of Agriculture, 2008-2018) and it is the problem of planted olives areas in Egypt.This habit causes severe loss for olive growers income expressed in disturbances in yearly income of the orchard and poor fruit quality. Environmental condition plays an important role in growth and productivity of olive cultivars as productivity varies according to environmental and climatic conditions [15, 16].

Studies concerning environmental conditions influenced olive trees behavior, specially its bearing habit, yield and fruit quality are still in need for further studies. Previous studies indicated that high temperatures (over 30°C) during blooming period induced reduction of fruit set in olive cvs [17].

Our aim was to design and test a deficit irrigation strategy RDI for a sustainable balance between water saving, tree vigour and oil production based on knowledge on the sensitivity of the olive tree to water stress at different phenological stages available at the applied to olive orchards. As well as, using some natural materials (kaolin) is sprayed over tree canopies for studying impact of these coefficients on alleviating direct solar radiation and reducing temperature of trees to improve the sex ratio values, increased significantly number of fruit set (%), number of fruit per meter, yield (Kg/tree) and quality.

MATERIALS AND METHODS

This work was conducted throughout two successive seasons of (2017 and 2018) on 17-years-old “Picual cv.” olive trees. The trees were raised by cuttings and planted at 6 x 6 m. (120 trees/fed.) apart in a sandy soil of a great private orchard at Al-Khatatba, Minufiya Governorate, Egypt at 30.6 N latitude, 31.01 S longitude, at an elevation of 17.9 m above sea level. They were of normal growth, uniform in vigour and subjected to drip irrigation system. Seventy two trees from Picual cv. each selected and divided in two factors; the first factor was four irrigation levels (80, 100 and 120% ETc beside the control) and the Kaoiln (non kaolin, spraying at 5 %) is the second factor. Treatment with three replicates (three trees for each replicate). The experiment treatments were arranged in a split-plot design in complete randomized block system with three replicates. Irrigation levels were rested in the main plots and kaoiln foliar spray occupied the sub plots.

This experiment was begun in the 1st March and continued during 2017 and 2018 growing seasons. The textur of the used soil was sandy soil. Surface soil samples (0-60 cm) were taken and air dried for carrying out physical and chemical analysis. Soil physical, chemical properties, soil water parameter and bulk density of experimental site were analyzed according to Cottein *et al* [18]; Kult [19] and Page *et al*. [20] as shown in Tables (1 and 2).

Table 1: Physical and chemical analysis of the orchard experimental soil

Parameter	Value	Parameter	Value
Clay %	6.52	Organic matter (%)	0.69
Silt %	1.24	O.C (%)	0.4
Sand %	92.24	C/N (%)	0.002
Soil texture (International Texture Classification)	Sandy	pH (1: 2.5 w/v soil : water suspension)	7.68
$CaCO_3$ (%)	1.42	EC dSm^{-1} (paste extract)	0.25
Cations and anions in soil paste extract ($meql^{-1}$		Macro (mg kg^{-1})	
Na^+	1.22	N	40
K^+	0.21	P	26
Ca^{2+}	2.02	K	128
Mg^{2+}	0.41	Micro (mg kg^{-1})	
CO_3^{2-}	0	Mn	18.6
HCO_3^-	0.81	Zn	1.2
Cl^-	1.52	Cu	0.2
SO_4^{2-}	1.53	Fe	3.3
		B	0.3

Table 2: Soil bulk density and moisture content values at the experimental site

	Available soil moisture		Moisture content at wilting point		Moisture content at field capacity		
Bulk density (gm/cm^3)	mm	w/w %	mm	w/w %	mm	w/w %	Soil depth (cm)
1.52	18.47	8.1	10.49	4.6	28.96	12.7	0-15
1.59	19.08	8	10.73	4.5	29.81	12.5	15-30
1.68	16.63	6.6	10.08	4	26.71	10.6	30-45
1.77	18.05	6.8	9.03	3.4	27.08	10.2	45-60
	72.23		40.33		112.56		Total

Table 3: Chemical properties of irrigation water samples

			Cations and anions ($meqL^{-1}$)							
EC (dSm^{-1})	pH	SAR	Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3^-	HCO_3^-	Cl^-	SO_4^{2-}
1.95	7.30	5.93	6.00	1.80	11.15	0.80	Nil	2.80	0.75	10.20
	S.S.P %				R.S.C				B mgL^{-1}	
	60.00				3.20				1.35	

Hydro – Physical Characters: As shown in Table (2). The values of field capacity varied from 10.2% (27.08 mm water /15 cm soil depth) to 12.7 % (28.96 mm water /15 cm soil depth) and decreased with increasing soil depth. Permanent wilting point values ranged from 3.4% (9.03 mm/15 cm soil depth) to 4.6% (10.49 mm/15cm soil depth) and also, decreased with increasing soil depth. Total available soil moisture content values in the soil profile (0 - 60 cm) were 72.23 mm water/ 60 cm. Values the of bulk density were 1.52, 1.59, 1.68 and 1.77 (gm/cm^3) for the soil depths from 0 – 15, 15 – 30, 30 – 45, cm and 45 – 60 cm, respectively.

In addition, the usual farm managements in the region were followed. The selected trees were fertilized with 20 m^3 analyzed organic manure/fed./year. The recommended water quantities for olive trees (1500-2000 cubic meter/fed) were used through drip irrigation system. The irrigation water samples were taken to determine the EC (Electrical Conductivity), pH, soluble cations [Ca^{++}, Na^+, Mg^{++} and K^+] and soluble anions [CO_3, HCO_3, Cl and SO_4] according to the methods described by Jackson [21] and Piper [22].

Meteorological Data: Temperature and relative humidity data at location was obtained by the National Meteorology Laboratory, Ministry of Agriculture.

Experimental Material: Designing experiment of using some natural materials (Kaolin) is sprayed over tree canopies for studying impact of these coefficients on alleviating direct solar radiation and reducing temperature each treatment. Kaolin is a clay mineral, part of the group of industrial minerals, with the chemical composition $Al_2Si_2O_5(OH)_4$. It is a layered silicate mineral, with one tetrahedral sheet of silica (SiO_4) linked through oxygen atoms to one octahedral sheet of alumina (AlO_6) octahedral. Rocks that are rich in kaolin are known as kaolin or china clay.

Table 4: Average of daily max. and min. temp. (°C); humidity (%); wind (m/s) and sunshine duration (hours) during the months of season, 2017and 2018

Month	Min. Temp. °C	Max. Temp. °C	Humidity (%)	Wind (m/s)	Sun (hours)	Rad (MJ/m^2/day)
			2017			
January	8.3	19.6	60.0	1.7	10.3	16.0
February	10.4	24.4	54.0	1.6	11.0	19.4
March	13.1	27.3	43.0	2.5	11.9	23.8
April	16.5	33.5	38.0	1.9	12.8	27.7
May	19.1	34.6	39.0	3.4	13.4	29.8
June	22.5	38.6	32.0	2.0	13.9	30.8
July	24.3	36.6	46.0	2.1	13.8	30.4
August	23.8	37.2	44.0	3.5	13.0	28.3
September	22.3	35.4	44.0	1.9	12.2	24.9
October	19.8	32.4	57.0	2.0	11.4	20.7
November	15.5	27.4	55.0	1.8	10.6	16.8
December	8.7	20.9	58.0	1.7	10.1	14.9
Average	17.0	30.7	48.0	2.2	12.0	23.6
			2018			
January	10.3	19.4	60.0	2.6	10.5	16.1
February	8.0	21.5	62.0	2.0	11.0	19.3
March	12.0	25.4	50.0	2.3	11.9	23.8
April	15.8	28.8	41.0	2.4	12.7	27.5
May	19.4	34.6	34.0	2.0	13.4	29.8
June	16.0	36.7	23.0	2.0	13.9	30.8
July	24.5	38.2	42.0	1.6	13.8	30.4
August	24.6	37.1	46.0	2.0	13.1	28.4
September	22.3	34.9	46.0	2.9	12.2	24.9
October	18.5	31.0	47.0	1.9	11.4	20.7
November	13.7	25.5	54.0	1.7	10.5	16.7
December	12.4	23.9	64.0	2.3	7.3	12.1
Average	16.5	29.8	47.0	2.1	11.8	23.4

On the other hand, aim was to design and test a regulated deficit irrigation (RDI) strategy for a sustainable balance between water saving, tree vigour and oil production. We considered three periods along the olive growing cycle on which the crop is more sensitive to water stress. Period 1 goes from the stages of floral development to full bloom. Enough water supply on these days favours flower fertilization [23]. The period 1 usually occurs in March and April, so full irrigation is needed. The Period 2 occurs at the end of the first phase of fruit development, i.e. on the week ca. 6 to 10 after full bloom (AFB) this usually occurs in June [24, 25]. Water deficit at this period has been reported to reduce fruit size [26]. Period 3 refers to a period of ca. 3 weeks mature prior to, when a marked increase in oil accumulation occurs, after the midsummer period of high atmospheric demand. Period 3 occurs in September. At this period 3 the olive tree is very sensitive to water stress [27, 28]. As activated irrigation treatments in March to September.

The experiment included six treatments as follows:

Irrigation Treatments (Main Plots):

- Irrigation with amount of water equals 100% of Etc (day after day) (control)
- Irrigation with amount of water equals 80 % of ETc of potential evapotranspiration (ETc) (irrigation daily).
- Irrigation with amount of water equals 100% of Etc (irrigation daily)
- Irrigation with amount of water equals 120% of ETc. (irrigation daily)

Foliar Applications (Sub-Plots):

- Foliar spray with water (untreated).
- Foliar spray Kaolin (5%) March, April, May and June acoording to Glenn and Puterka [7]; Raslan *et al*. [29] and Mohamed-Hoda *et al*. [30].

Drip Irrigation System: The drip irrigation system used in the farm included an irrigation pump (50 hp) connected to sand and screen filters and a fertilizer injector tank. The conveying pipeline system consists of a main line that is made of PVC pipe of 76.2 mm diameter connected to sub-main line of 50.8 mm and manifold of 38.1mm. The drip lateral lines of 16mm diameter are connected to the manifold line. Each tree line is served by two lateral lines about 2 m apart (i.e., 1m from each side of the pseudo stems). Lateral lines were equipped with build-in emitters of 4 l/h discharge and spaced 0.50 m apart on the lateral line.

Table 5: Penman- Monteith (ETo) formulae in 2017 and 2018 seasons

	Penman- Monteith (ET_o)			
Season	2017		2018	
Month	mm/day	mm/month	mm/day	mm/month
January	2.29	71.0	2.78	86.2
February	3.23	90.4	3.04	85.1
March	5.21	161.5	4.63	143.5
April	6.42	192.6	6.15	184.5
May	7.82	242.4	7.35	227.9
June	8.20	246.0	7.87	236.1
July	8.49	263.2	7.50	232.5
August	8.76	271.6	7.42	230.0
September	6.33	189.9	7.16	214.8
October	4.86	150.7	4.86	150.7
November	3.49	104.7	3.17	95.1
December	2.39	74.1	2.66	82.5
Seasonal (mm)		2058.0		1969.0

Crop-Soil-Water Relations

Reference Crop Evapotranspiration (ET_o): ET_o values were calculated based on local meteorological data of the experimental site (Table 3) and according to the Penman-Monteith equation FAO [31]. Calculations were performed using the CROPWAT model [32].

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

where:

- ET_o : Reference evapotranspiration (mm day^{-1}),
- R_n : Net radiation at the crop surface (MJ m^{-2} day^{-1}),
- G : Soil heat flux density (MJ m^{-2} day^{-1}),
- T : Mean daily air temperature at 2 m height (°C),
- u_2 : Wind speed at 2 m height (ms^{-1}),
- e_s : Saturation vapor pressure (kPa),
- e_a : Actual vapor pressure (kP)
- e_s-e_a : Vapor pressure deficit (kPa),
- Δ : Slope of the vapor pressure-temperature curve (kPa °C^{-1}),
- γ : Psychrometric constant (kPa °C^{-1})

Crop Evapotranspiration (Etc): The ETc values were calculated according to the following equation given by FAO [33]:

ETc = ETo X Kc

where:

- ET_c : Crop evapotranspiration (mm day^{-1})
- ET_o : Potential evapotranspiration (mm/day) values obtained by Penman- Monteith equation.
- Kc : Crop coefficient: Current Kc values published for olive are given based on three growth stages: initial, KCi =0.5; middle Kcm = 0.65; and late development KCe = 0. 5 [34].

Amount of Applied Irrigation Water (AIW): The amount of applied water was measured by a flow meter and was calculated according to the following equation FAO [35]:

$$AIW = \frac{Sp\ XS_l\ X\ ET_c\ XKr\ X\ Iinterval}{Ea} + LR$$

where:

- AIW = Applied irrigation water depth (liters/day).
- Sp = Distance between plants in the same line (m).
- S_l = Distance between lines (m).
- ETc = Crop evapotranspiration (mm day^{-1})
- K_r = Reduction factor that depends on ground cover. It equals 0.7 for mature trees FAO [36] and Fereres *et al*. [37].
- E_a = Irrigation efficiency it equals 90 %
- $I_{interval}$ = Irrigation intervals (days) = 1 day for the experimental site.

LR = leaching requirements FAO [33] = $\frac{EC_w}{2MaxEC_e}$

where:

- EC_w = Electrical conductivity of the irrigation water (1.2 dS/m).
- Max EC_e = Maximum tolerable electrical conductivity of the soil saturation extract for banana crop (5 dS/m).

Water Utilization Efficiency (W.Ut.E): Applied irrigation water is used to describe the relationship between production and the amount of water applied. It was determined according to the following equation [38]:

$$W.Ut.E = \frac{Fruit\ yield\ (kg)/feddam}{Seasonal\ AIW\ (m^3 water\ applied / feddan)}$$

Seasonal AIW (m^3 Water Applied/Feddan): As it is activated in March and April (bloom development), May and June. Each tree received 5 L. of spray solution till runoff with Triton B at 0.1 % as a wetting agent by using a backpack spray apparatus, in addition to control which was only sprayed with water. The following parameters were measured:

Flowering:

Flowering Time and Duration: Blooming dates: Beginning and end of flowering dates were recorded when 25% and 75%, respectively of the total flowers opened [39].

Blooming Periods: Calculated as the days between beginning of flowering and ending of blooming [40].

Beginning of flowering; full bloom and end of flowering was recorded. Flowering duration was also determined from beginning and end of flowering in both seasons of the study.

Number of Inflorescences per Meter: Ten shoots (one year old) were chosen at random and labeled for each replicated tree. Average numbers of inflorescences per shoot and per meter were calculated.

Total Number of Flowers per Inflorescence: Thirty inflorescences at the middle portion of the shoot were randomly chosen from inner and outer portion of the tree canopy to determine the number of flowers per inflorescence.

Perfect flowerer percent: calculated according to Hegazi and Stino [41]; Rallo and Fernández-Escobar [42] and Hegazi [43]) as the following equation:

$$\text{Perfect flower percentage} \frac{\text{No. of perfect flowers}}{\text{No. of total flowers}} x100$$

Length of Inflorescence (cm): Thirty inflorescences were randomly chosen from inner and outer portion of the tree. Average length of inflorescence in the middle portion of shoots were recorded

Number of inflorescences per shoot: the labeled twenty shoots were calculated.

Number of Total Flowers per Inflorescence: Sample of 20 inflorescences was taken from each tree and total number of flowers per inflorescences was counted.

The percentage of perfect flowers to total flowers was calculated for each replicate.

Fruit Set (%): Fruit set were calculated after 60 days from full bloom according to Hegazi and Hegazi [44] and Hegazi *et al*. [2] as a formula:

$$\text{Fruit set \%} = \frac{\text{No. of fruits}}{\text{No. of total flowers}} x100$$

Fruit drop:

Fruit drop (%) = [(Initial fruit set - Final fruit set) / Initial fruit set] × 100.

Yield; Fruit Physical and Chemical Characteristics

Fruit and Seed Dimensions: Length (L) and width (W) of 30 fruits/cultivar (10 fruits/replicate) were measured using Averner Caliper and the averages were recorded in centimeters then shape index (L: W) was calculated. Seed length & width was also measured and shape index (L: W) was calculated.

Fruit Fresh Weight: It was determined by weighing the fresh fruit samples and average fruit weights were recorded in grams.

Pulp Weight and Seed Weight: The average weight of seed (g.) was recorded as grams, pulp weight/seed ratio were calculated.

Fruit Yield: Fruit yield was recorded as Kg/ tree.

Chemical Characteristics

Oil Content Percentage: The oil content was determined by extracting the oil from the dried fruit samples using petroleum ether at 60-80°C boiling points by soxhlet fat extraction apparatus as described in the A.O.A.C. [45].

Moisture Content (%): Moisture content of the fruit was determined by oven drying the samples at 70°C until constant weight, then moisture percentage was calculated [45].

Soil Analysis: Particle size distribution: Mechanical analyses of the soil at the experimental site (sand, silt and clay percentages and soil texture class) were determined according to the International method Klute [19].

Soil Bulk Density: Bulk density was determined in undisturbed soil samples using the core method acoording to Black and Hartge [46].

- Field capacity (F.C.) and permanent witting point (PWP) were demined by mean of the pressure cooker and pressure membrane, respectively for moisture content at pressures of 0.33 and 15.0 bar according to Klute [19]. Nitrogen was determined by micro Keldahl, according to Cottenie *et al*. [18].

- Electrical conductivity of soil saturation extract (EC), pH, cations and anions also Potassium was determined by a flame photometer were determined according to Page *et al*. [20]. Fe, Mn and Zn were determined by using Atomic Absorption (model GBC 932).

Economic Evaluation: Economic evaluation was calculated according to Heady and Dillon [47] as follows:

Number of trees/Fedden= 120 trees - Amount of sprays/tree = 5 Litter
Amount of sprays/Fedden in January = 5 x 120 trees = 600 litter.
Amount of sprays/Fedden in (March, April, May and June) = 2400 Litter
Price of Kaolin (Kg) =10 L.E.
Cost of spraying treatments /Fadden = amount of spraying treatments (kg) /Fedden × price of spraying treatments/feddan
Fixed expenses (cost of the spraying unit and labor cost = 100 L.E. for each spray
Total cost of spraying= cost of spraying treatments/ Fedden + fixed expenses
Total gross income =average yield of two seasons (kg)/Fedden × price/ kg
Price/kg of Picual (8 L.E).
Average net return = total gross income - total cost of spraying and irrigation.

Statistical Analysis: The experiment was arranged in a randomized complete blocks design and the obtained data were subjected to analysis of variance according to Snedecor and Cochran [48]. In addition significant differences among means were distinguished according to the Duncan multiple tests range [49].

RESULTS AND DESSCUTION

Water Relations

The Estimated Evapotranspiration ET_c: Crop water use of mature olives (ET_c) is determined by multiplying the reference ET_o by the olive crop coefficient (Kc). The ET_c was calculated from climate data for both seasons to estimate the water requirement for olive tree. Data in Fig. (1) illustrate the results of the ETc calculations for experiment site. The highest monthly ETc during July and August were (5.52 and 4.82) and (4.88 and 4.08) mm/day for first and second seasons, respectively, while the lowest ETc value occurs in January and December were (1.15 and 1.20) and (1.39 and 1.33) mm/day in both seasons, respectively. The ETc at 2017 season was increased than ETc at 2018 season. These results agreed with those of El-Taweel and Farag [50].

Applied Irrigation Water (AIW): A deficit irrigation regime at several levels of water reduction is outlined in Table 4. The effect of tested irrigation treatments on applied irrigation water expressed as liters/tree/day, m^3/fed/month and m^3/fed/year for the 2017 and 2018 growing seasons. Results show that amounts of applied irrigation water were 3835, 3079, 3849 and 4619 m3/fed./year in first season and 3835, 2934, 3669 and 4403 m3/fed./year in second season for the (120 % ETc), (100 % ETc), (80 % ETc) and (irrigate the farm) irrigation treatments, respectively. The applied irrigation water decreased by 33.4 %, 20.1 % and 21.7 % (means of the 2 seasons) under 80 % ETc, 120 % Etc, 100 % ETc and control (irrigate the farm), respectively. The compare to values showed that seasonal water applied by olive trees are higher in the first than in the second season. Such results are mainly due to differences in climatic factors. These results are in agreement with Goldhamer [51] indicate that the deficit irrigation regime that saves about 25% (200 mm) of full ETc may be useful in conserving water while maintaining top yields of high quality fruit. Also, several studies Gucci *et al*. [52] indicate that regulated deficit irrigation in olive may be suitable to improve physiological balances with a limited input supply. Several studies have shown that irrigation has a large effect on the productivity of olive farms [53].

Monthly Applied Irrigation Water For some crops, primarily perennial crops, there may be growth periods when the crop can be deficit irrigated with minimal impact on yield and quality. Taking advantage of these periods, drib systems can apply precise irrigations to deficit irrigate without overly stressing the crop.

Monthly applied irrigation water Fig. 2 was full ETc 100 % was met, 120% ETc and 80% ETc in the Spring from early March to late April (bloom development), June (fruit development) and September (oil accumulation occurs).

This agree with the need of avoiding water deficit on the first weeks of pit hardening, when active cellular division occurs in the fruits, reported by Gucci *et al*. [54].

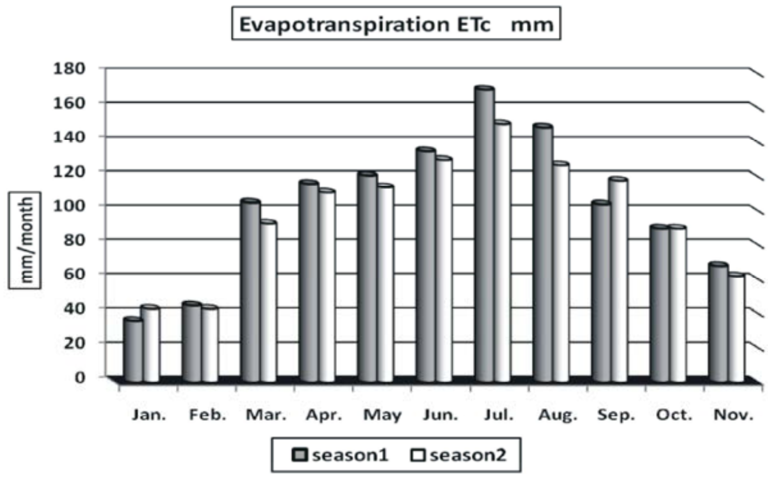
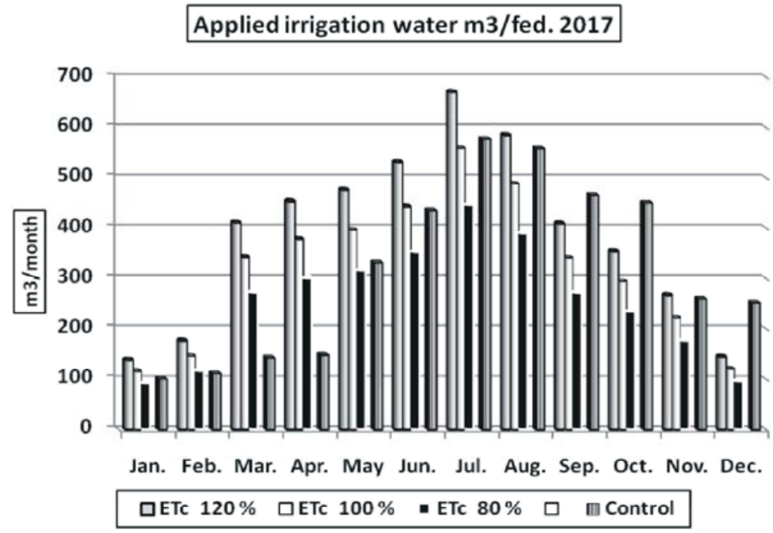


Fig. 1: The estimated Evapotranspiration (Etc) during two growing seasons 2017 and 2018 for experiment site

Table 6: Effect of irrigation treatments on the amounts of applied irrigation water for the 2017 and 2018 growing seasons

	2017							
	ET_c 120 %		ET_c 100 %		ET_c 80 %		Irrigate the farm Control	
Month	L/tree /day	m^3/fed /month	L/tree /day	m^3/fed /month	L/ tree /day	m^3/fed /month	L/ tree /day	m^3/fed /month
Jan.	37.5	139.5	31.3	116.3	24.9	93	27.2	101
Feb.	52.7	177.0	43.9	147.5	35.2	118	33.3	112
Mar.	110.5	411.0	92.1	342.5	73.7	274	38.7	144
Apr.	125.8	453.0	104.9	377.5	83.9	302	41.4	149
May	127.8	475.5	106.5	396.3	85.1	317	89.2	332
Jun.	147.5	531.0	122.9	442.5	98.2	354	120.7	435
Jul.	180.2	670.5	150.2	558.8	120.2	447	155.1	577
Aug.	157.3	585.0	131.0	487.5	104.9	390	150	558
Sep.	113.8	409.5	94.8	341.3	75.8	273	129.2	465
Oct.	95.2	354.0	79.3	295.0	63.5	236	120.9	450
Nov.	74.2	267.0	61.8	222.5	49.4	178	72.2	260
Dec.	39.1	145.5	32.6	121.3	26	97	67.7	252
Total	4619		3849		3079		3835	
	2018							
Jan.	45.6	169.5	38.0	141.3	30.3	113	27.2	101
Feb.	49.6	166.5	41.3	138.8	33.1	111	33.3	112
Mar.	98.4	366.0	82.0	305.0	65.5	244	38.7	149
Apr.	120.4	433.5	100.3	361.3	80.4	289	41.4	144
May	120.2	447.0	100.1	372.5	80.1	298	89.2	332
Jun.	141.3	508.5	117.7	423.8	94.3	339	120.7	435
Jul.	159.3	592.5	132.7	493.8	106.2	395	155.1	577
Aug.	133.5	496.5	111.2	413.8	88.9	331	150	558
Sep.	128.8	463.5	107.3	386.3	85.8	309	129.2	465
Oct.	95.2	354.0	79.3	295.0	63.5	236	120.9	450
Nov.	67.5	243.0	56.3	202.5	44.9	162	72.2	260
Dec.	43.5	162.0	36.3	135.0	29	108	67.7	252
Total	4403		3669		2934		3835	

As shown in Fig. 2, with our RDI strategy irrigation supplies must replace or be close to the crop water needs at periods 1, 2 and 3. From late June to late August, i.e. between periods 2 and 3, the olive tree is highly resistant to drought, so irrigation supplies can be markedly reduced [55].



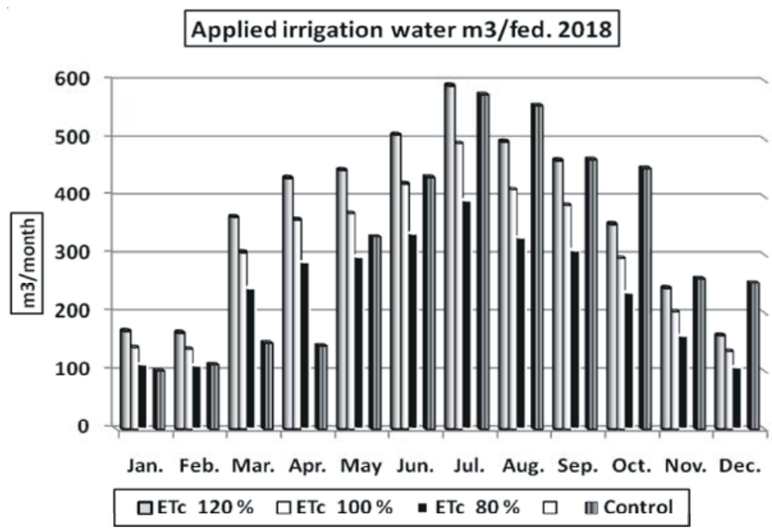


Fig. 2: Monthly water consumptive use m^3/month for olive trees as affected by different irrigation treatments during 2017 and 2018 seasons

Enough water supply on these days (April) favours flower fertilization [23]. Water deficit at this period (June) has been reported to reduce fruit size [26].

A wrong, badly managed DI strategy, however, may cause severe water deficit at stages when the crop is most sensitive to water stress, reducing both the yield of the current year and the productive life of the orchard [56]. Monthly applied irrigation water Fig. 2 was low at the beginning of the growth season. This can be related to less transpiring surface leaves during the period of first growth. Potential evapotranspiration was low through this period Table 6, then increased gradually as the green cover increased with increases in air temperature and solar radiation. The highest applied irrigation water occurred during July reflecting: expansion of the leaf system, growth of fruit on a volume basis and high solar radiation and air temperature. The July and August values for the treatments averaged (631.5 and 540.8), (526.3 and 450.7) and (441 and 360.5) m^3/fed. (means of the 2 seasons) for the 120 % ETc, 100 % ETc and 80 % ETc irrigation treatments, respectively.

Thereafter, evapotranspiration rate decline to reach its minimum value from October to January as the trees were end period harvest. Such results can be attributed to high evaporation than transpiration early in the season as plants intercepts little of net radiation. Later, as the green cover expanded, transpiration was greater than evaporation. Thus, the increase in evapotranspiration from the beginning of the growth season till fruit maturity can be explained on the basis of the cover. Goldhamer's study Goldhamer *et al*. [57] showed that olives perform best under these optimal conditions, but will survive extremely water-stressed conditions, as they are naturally drought tolerant trees. Before any sort of regulated deficit drought irrigation strategy can be managed the timing and amount of what constitutes full olive irrigation must be understood. In addition, environmental condition play an important role in growth and productivity of olive cultivars as productivity vary according to climatic condition and environment [15].

Water Utilization Efficiency (W.Ut.E): Water utilization efficiency is represented here as the amount of yield produced by one cubic meter of irrigation water used by crop.

Results in current study indicated that, there was significant effect of the amounts of applied irrigation on W.Ut.E value Table (7). The obtained values were significantly different under irrigation treatments the main effect of irrigation treatments the values of water utilization efficiency for olive trees as affected by the amounts of applied irrigation. The sustained deficit irrigation ETc 80 % gave the highest water use efficiency. While under irrigate the farm were lower, the values were as follows: irrigate the farm = 0.63 kg, ETc 80 % = 1.19, ETc 100 % = 0.88, ETc 120 % = 0.69 and fruit/m3 water (means of the 2 seasons). Thus ETc 80 %, ETc 100 % and ETc 120 % gave 89.6, 40.2 and 10.0 % more efficiency than irrigate the farm respectively. The mean values of WUE gradually decreased with increasing water quantity. These results are in agreement with those reported by Zeng *et al*. [58] who found that the lower amount of irrigation water applied, the higher irrigation water use efficiency obtained and Tiwari *et al*. [59] who found that the yield per unit quantity of water used increased by increasing water deficit. Costa *et al*. [60] found that previous studies indicate that deficit irrigation strategies can improve WUE and saving irrigation water in several important horticultural crops and especially those typically tolerant to water stress.

The main effect of foliar spray with kaolin shows that all spray with amino acids increased WUtE as compared with (control) the spray with water treatments. Mean values were as follows: 1.0 and 0.69 kg fruit/m^3 water (means of the 2 seasons), by spraying kaolin and the spray with water (control), respectively. Thus foliar spray with kaolin gave 45.4 % more efficiency than (control) the spray with water treatment.

Also, maximum water utilization efficiency values were 1.56 and 1.23 kg fruit/m^3 water by irrigation ETc 80 % and kaolin 5% in both seasons.

These results are in agreement with those reported by Saif El-Din and Abd El-Hamed [61] found that kaolin at 6% as antitranspirants was the best combination for globe artichoke production which resulted in maximum water use efficiency. Boari *et al*. [62] found that use of kaolin creates a canopy cover (over the above-ground part of the plant and fruits), which reduces the water loss by transpiration. In addition to increasing WUE and improving fruit quality, kaolin increases the proportion of first-class yields. Treatments including kaolin also reduce sunburn to a large extent.

The present study involved two main factors i.e. spraying of Kaolin and irrigation levels (control "80 L/tree day after day), irrigation daily by ETc 80, 100 and 120 % L/tree daily) and Kaolin (0.0 and 5 %). The actual treatments involved all the possible combinations of the two main factors (kaolin and irrigation levels) on Picual cv. blooming, fruiting aspects, characteristics and fruit chemical content during 2017 and 2018 seasons, respectively.

Blooming Characteristics: Concerning the specific effect of the different irrigation levels on No. of inflorescence and No. of total flowers/inflorescence of Picual cv., data presented in Table (8) indicated that, the highest values in No. of inflorescence/ shoot and No. of total flowers/inflorescence were resulted by the rate of (Etc 80 %) in both seasons, whereas the opposite trend were detected with the rate of irrigate the farm (control) in both seasons, respectively. Dealing with the specific effect of the two investigated factors on No. of inflorescence/ shoot and No. of total flowers/ inflorescence, data presented in the same Table, reflected that kaolin foliar spraying at 5 % had a higher significant value of No. of inflorescence/shoot and No. of total flowers/inflorescence than the control (0.0 %) during 2017 and 2018 seasons. In addition to that, other treatments gave intermediate values in both seasons of study.

Whereas, the specific effect of the different irrigation levels on inflorescence length (cm), the irrigation levels of (Etc 80 and 100 % daily) gave the highest values with

Table 7: Effect of amounts of applied irrigation water and Spraying of kaolin on water utilization efficiency for the 2017 and 2018 growing seasons

	Water utilization efficiency (W.Ut.E):		
	Kaolin		
Irrigation levels	Untreated	5%	Mean
	First season; 2017		
ETc 100 % (day after day) (control)	0.63e	0.94c	0.78C
ETc 80 %	0.96b	1.56a	1.26A
ETc 100 %	0.70d	1.15b	0.93B
ETc 120 %	0.55f	0.91c	0.73D
Mean	0.71B	1.14A	
	Second season; 2018		
ETc 100 %(day after day) (control)	0.31g	0.63e	0.47D
ETc 80 %	1.00b	1.23a	1.12A
ETc 100 %	0.78e	0.88c	0.83B
ETc 120 %	0.59f	0.71d	0.65C
Mean	0.67B	0.86A	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level

non significant in between, in both seasons. Concerning the inflorescence length (cm) data in the same Table showed that the specific effect of spraying of kaolin at (0 and 5 %) took the same trend for two previous parameters (No. of inflorescence/shoot and No. of total flowers/ inflorescence) was the highest values at 5 % than the control (0.0 %) during two seasons.

Regarding the interaction effect of the two investigated factors i.e., kaolin foliar application and the different irrigation levels (ETc 80, 100 and 120 %) beside control (irrigation farm) on No. of inflorescence/shoot and No. of total flowers/inflorescence, data in Table (8) revealed that, Kaoiln at (5 %) x irrigation (80 %) in the first and second seasons, treatment gave the highest value at the No. of inflorescence/shoot and No. of total flowers/inflorescence. On the other hand, the lowest value of No. of inflorescence/shoot and No. of total flowers/inflorescence, were detected with control during first and second seasons of study.

In regard to the interaction effect of the two investigated factors i.e., different irrigation levels (ETc 80, 100 and 120 %/ L/tree daily) beside control (irrigation farm) and kaolin foliar application on inflorescence length (cm), data are recorded in the same Table quite clear, the best result regarding inflorescence length (cm) was obtained with Kaolin (5 %) combined with two irrigation levels Etc 80 and 100 % daily, during both seasons, respectively. These results were in agreement with those obtained by Al-Khawaga [16] and Saad El-Din-Ikram *et al*. [63, 64].

Considering the specific effect of different irrigation levels (80 %, 100 % and 120 from ETc L/tree daily) beside the control (Etc 100% day after day) and foliar application of kaolin (0 and 5 %) on No.of perfect flowers per inflorescence, perfect flowers (%) and fruit set/m of olive "Picual" cv., data presented in Table (9) obviously show that, the foliar application of kaolin at (5 %) had the highest values of No.of perfect flowers per inflorescence, perfect flowers (%) and fruit set /m than the kaolin (0.0) during both seasons of study.

With respect to the specific effect of different irrigation levels on No.of perfect flowers per inflorescence, perfect flowers (%) and set fruit/m, data recorded in Table (9), mentioned that all the investigated treatments significantly increased No.of perfect flowers per inflorescence, perfect flowers (%) and set fruit/m of Picual cv. compared with control which was irrigation levels with “80 % ETc” per tree daily in the first and second seasons. Meanwhile, the opposite trend was detected with the which exhibited statistically the least No.of perfect flowers per inflorescence, perfect flowers (%) and set fruit/m the (control) during two seasons of study.

Regarding the interaction effect of the two investigated factors i.e., the different rates of irrigation and Kaoiln foliar application on No.of perfect flowers per inflorescence, perfect flowers (%) and set fruit/m, data presented in Table (9) clear obviously that the most simulative combination enhanced in No.of perfect flowers per inflorescence, perfect flowers (%) and set fruit/m was

Table 8: Effect of Kaolin spraying 5 % and different irrigation levels on flowering of Picual cv. during 2017 and 2018 seasons

	No. of inflorescence /shoot			Inflorescence length (cm)			No. of total flowers/ inflor.		
	Kaolin			Kaolin			Kaolin		
	Untreated	5%	Mean	Untreated	5%	Mean	Untreated	5%	Mean
Irrigation levels					First season 2017				
ETc 100 % (day after day) (control)	7.73e	8.15d	7.94D	2.33bc	2.35bc	2.34B	9.99e	10.10e	10.05C
ETc 80 %	9.17b	9.89a	9.53A	2.37b	2.44a	2.41A	12.75b	13.46a	13.11A
ETc 100 %	8.21d	8.89c	8.55B	2.31c	2.43a	2.37AB	11.92d	12.53bc	12.23B
ETc 120 %	7.89e	8.35d	8.12C	2.19d	2.37b	2.28C	11.70d	12.44c	12.07B
Mean	8.25B	8.82A		2.30B	2.40A		11.59B	12.13A	
					Second season 2018				
ETc 100 % (day after day) (control)	7.30e	7.50e	7.40C	2.12d	2.23c	2.18B	9.06e	9.37d	9.22C
ETc 80 %	8.57b	9.33a	8.95A	2.10de	2.42a	2.26A	10.07ab	10.25a	10.16A
ETc 100 %	7.76d	8.33c	8.05B	2.14d	2.39a	2.27A	9.84bc	9.93bc	9.89B
ETc 120 %	7.92d	8.21c	8.07B	2.03e	2.31b	2.17B	9.68c	9.88bc	9.78B
Mean	7.89B	8.34A		2.10B	2.34A		9.66B	9.86A	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level

Table 9: Effect of Kaolin spraying 5 % and different irrigation levels on flowering of Picual cv. during 2017 and 2018 seasons

	No. of Perfect flowers / Inflorescence			Perfect flowers (%)			Fruit set /m		
	Kaolin			Kaolin			Kaolin		
	Untreated	5%	Mean	Untreated	5%	Mean	Untreated	5%	Mean
Irrigation levels					First season 2017				
ETc 100 % (day after day) (control	4.53e	4.93d	4.73C	48.81e	45.35f	47.08C	30.00g	35.00f	32.50D
ETc 80 %	7.78b	8.07a	7.93A	59.65cd	63.68a	61.66A	42.60cd	49.48a	46.04A
ETc 100 %	7.31c	7.40c	7.36B	59.96c	61.02b	60.49B	41.94d	45.00b	43.47B
ETc 120 %	7.45c	7.42c	7.44B	59.06d	61.33b	60.19B	39.74e	42.90c	41.32C
Mean	6.77B	6.96A		56.87B	57.84A		38.57B	43.10A	
					Second season 2018				
ETc 100 % (day after day) (control)	4.10f	4.50e	4.30C	45.25f	48.03e	46.64D	25.00g	30.00f	27.50D
ETc 80 %	5.17bc	5.38a	5.28A	51.96bc	53.34a	52.65A	37.42d	40.77a	39.10A
ETc 100 %	4.92d	5.22b	5.07B	51.34c	52.49ab	51.91B	36.87d	39.37b	38.12B
ETc 120 %	5.03cd	5.27ab	5.15B	50.00d	52.57ab	51.28C	35.99e	38.51c	37.25C
Mean	4.81B	5.09A		49.64B	51.61A		33.82B	37.16A	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level

that combination between kaolin (5 %) and irrigation levels with (80 %) during the two seasons. Moreover, the lowest decrease in No.of perfect flowers per inflorescence, perfect flowers (%) and set fruit/m was detected by (0.0) with control treatment during 2017 and 2018 seasons. On the other hand, other combinations treatments were in between in this respect. These results were approved with those obtained by Al-Khawaga [16]; Saad El-Din-Ikram *et al*. [63, 64] and Raslan *et al*. [29].

Concerning the Beginning of blooming, full bloom and blooming duration are presented in Table (10) and Fig. (3). It is appeared that, all the investigated trees bloomed at nearly the same date with no differences between treatments. The blooming duration lasted about 14 days from April, 9 to April, 22nd in the 2017 season and 14 days from April, 7 to April, 18th in 2018 season, respectively in all treatments. Full blooming date, however, was at in all the investigated trees full blooming date was at April 15 and 13 in the first and second seasons, respectively. As a general trend, blooming started by about 2days earlier in the second season than in the first. These results were in agreement with those obtained by Magliulo *et al.* [65] and Gomez-Rico *et al.* [66].

Table 10: Effect of Kaolin spraying 5 % and different irrigation levels on beginning of flowering, full bloom and end of flowering of Picual cv. during 2017 and 2018 seasons

	First season; 2017			Second season; 2018		
Treatments	Beginning of flowering	Full bloom	End of flowering	Beginning of flowering	Full bloom	End of Flowering
ETc 100 % (day after day) (control)	7 April	13 April	18 April	9 April	15 April	22 April
Kaolin 5% in 1st March	7 April	13 April	18 April	9 April	15 April	22 April
ETc 80 %	7 April	13 April	18 April	9 April	15 April	22 April
ETc 100 %	7 April	13 April	18 April	9 April	15 April	22 April
ETc 120 %	7 April	13 April	18 April	9 April	15 April	22 April

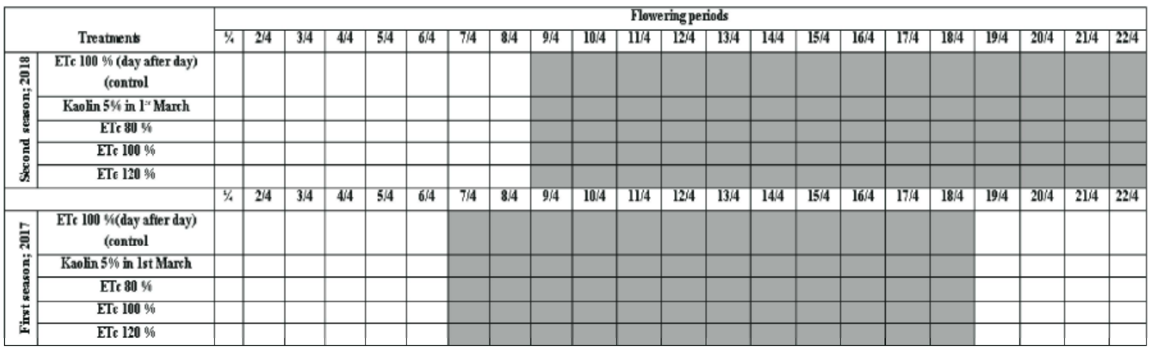


Fig. 3: Effect of Kaolin spraying 5 % and different irrigation levels on beginning of flowering; full bloom and end of flowering of Picual cv. during 2017 and 2018 seasons

Table 11: Effect of Kaolin spraying 5 % and different irrigation levels on number of remained fruits (m), fruit drop (%) and yield (kg)/tree of Picual cv. during 2017 and 2018 seasons

	Number of remained fruits (m)			Fruit drop (%)			Yield (kg/tree)		
	Kaolin			Kaolin			Kaolin		
Irrigation levels	Untreated	5%	Mean	Untreated	5%	Mean	Untreated	5%	Mean
					First season 2017				
ETc 100 % (day after day) (control)	17.00d	21.33c	19.17C	28.90a	27.06b	27.98A	20.00h	30.00d	25.00D
ETc 80 %	21.44c	23.90a	22.67A	23.40d	22.50e	22.95C	24.54h	40.00a	32.27A
ETc 100 %	21.18c	23.50ab	22.34AB	23.95c	23.70cd	23.83B	22.38f	37.00b	29.69B
ETc 120 %	20.92c	23.10b	22.01B	24.10c	23.80c	23.95B	21.15g	35.00c	28.08C
Mean	20.14B	22.96A		25.09A	24.27B		22.02B	35.50A	
					Second season 2018				
ETc 100 % (day after day) (control)	13.40f	18.10e	15.75D	30.40a	28.00b	29.20A	10.00h	20.00g	15.00D
ETc 80 %	20.66bc	23.85a	22.26A	21.80e	21.00f	21.40D	24.55d	30.00a	27.28A
ETc 100 %	18.79d	20.91b	19.85B	22.64d	22.00e	22.32C	23.71e	27.00b	25.36B
ETc 120 %	18.37de	20.34c	19.36C	23.75c	23.00d	23.38B	21.47f	26.00c	23.74C
Mean	17.81B	20.80A		24.65A	23.50B		19.93B	25.75A	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level

Dealing the different irrigation levels on number of remained fruits/m and yield (kg/tree) of Picual cv., data presented in the Table (11) indicated that, the highest values in No. of remained fruits/m and yield (kg/tree) were resulted by the rate of (80 %) in both seasons, whereas the opposite trend were detected with the rate of irrigate the farm (control) in both seasons, respectively. In addition to that, other treatments gave intermediate values in both seasons of study. In this respect with the specific effect of the two investigated factors on number of remained fruits/m and yield (kg/tree), data presented in Table (11), reflected that kaolin foliar spraying at 5 % had a higher significant value of number of remained fruits/m and yield (kg/tree) than the control (0.0 %) during 2017 and 2018 seasons.

Concerning, the specific effect of the different irrigation levels on the fruit drop (%), the irrigation level of the farm gave the highest significant values in both seasons. Whereas the fruit drop (%) data in the same Table showed that the specific effect of spraying of kaolin at (0 and 5 %) took the opposite trend were detected for previous parameter (the fruit drop (%)) was the highest values control at 0 % than the kaolin (5%) during two seasons.

Regarding the interaction effect of the two investigated factors i.e., the different irrigation levels (ETc 80, 100 and 120 %) beside control (irrigation farm) and Kaolin foliar application on No. of remained fruits/m and yield (kg/tree), data in Table (11) revealed that, Kaoiln at (5 %) x irrigation (80 %) in the first and second seasons, treatment gave the highest value at the No. of remained fruits/m and yield (kg/tree), On the other hand, the lowest value of No. of remained fruits/m and yield (kg/tree), were detected with control during first and second seasons of study.

As for regarding the interaction effect of the investigated factor i.e., the different rates of irrigation and Kaolin foliar application on fruit drop (%), data are recorded in the same Table it is quite clear from data, was that combination between kaolin (5 %) and irrigation level 80 %, the lowest decrease in fruit drop (%) was detected by with Kaolin (5 %) combined with irrigation level 80 %, during both seasons, respectively which reflect a very positive effects in this concern. These results were in agreement with those obtained by Al-Khawaga [16]; Saad El-Din-Ikram *et al*. [63, 64]; El-Sayed *et al*. [67]; Lavee [68]; Brito *et al*. [14]; Raslan *et al*. [29] and Mohamed-Hoda *et al*. [30].

Fruit and Seed Characteristics: The fruit characteristics presented in Tables (12, 13 and 14), it is obvious that the irrigation daily by (ETc 80, 100 and 120%) and spraying of Kaolin in 1st March, April, May and June on fruit and seed characteristics of Picual cv. influenced significantly the majority of fruit and seed characteristics in comparison with the contol during the two growing seasons.

Dealing with the specific effect of the different irrigation levels on fruit length (cm), fruit diameter (cm) and fruit weight (g) of Picual cv., data presented in the same Table indicated that, the highest values in fruit length (cm), fruit diameter (cm) and fruit weight (g) were resulted by the rate of (80 %) in both seasons, whereas the opposite trend were detected with the rate of irrigate the farm (control) in both seasons, respectively. Concerning the specific effect of the two investigated factors on fruit length (cm), fruit diameter (cm) and fruit weight (g), data presented in Table (12), reflected that kaolin foliar spraying at 5 % had a higher significant value of No. fruit length (cm), fruit diameter (cm) and fruit weight (g) than the control (0.0 %) during 2017 and 2018 seasons. In addition to that, other treatments gave intermediate values in both seasons of study.

Regarding the interaction effect of the two investigated factors i.e., the different irrigation levels (ETc 80, 100 and 120 %) beside control (irrigation farm) and Kaolin foliar application on fruit length (cm), fruit diameter (cm) and fruit weight (g), data in the same Table revealed that, Kaoiln at (5 %) x irrigation (80 %) in the first and second seasons, treatment gave the highest value at the fruit length (cm), fruit diameter (cm) and fruit weight (g). On the other hand, the lowest value of fruit length (cm), fruit diameter (cm) and fruit weight (g), were detected with control during first and second seasons of study. On the other hand, other combinations treatments were in between in this respect.

As regard the different irrigation levels on seed length of "Picual cv.", data reported in Table (13) the highest values in seed length was resulted by the highest level of (ETc 80 %) in both seasons, respectively, while, on the other side, the lowest significant with irrigate the farm (control) in both seasons, respectively. With respect to the specific effect of the two investigated factors on seed length (cm), data revealed in the same Table, showed that Kaolin foliar spraying at 5 % had a superiority significant value of seed length (cm) than the untreated (0.0 %) during 2017 and 2018 seasons. Moreover, other treatments were intermediate the above mentioned two extents with relatively variable tendency of effectiveness.

Concerning, the specific effect of the different irrigation levels on the seed diameter was the highest values were irrigation levels (ETc 120 and 80 %) with non significant between them in the first season, but the non significant differences with any levels of irrigation in second season. As regard to the seed weight (gm) there is not any significant values during 2017 season, but the highest significant values with irrigate the farm (control) and (ETc 120 %) in 2018 season. However, the seed diameter and seed weight, data in the same Table showed that the specific effect of spraying of Kaolin at (0 and 5 %) the differences were insignificant as seed diameter and seed weight of trees received any of Kaolin (untreated) and (treated) treatments were compared each other. Such trend was true during both 2017 and 2018 seasons of study.

Concerning the interaction effect between different irrigation levels beside control and Kaolin (0.00 & 5 %) on seed length of "Picual cv." olive trees, data revealed

Table 12: Effect of Kaolin spraying 5 % and different irrigation levels on fruit characteristics of Picual cv. during 2017 and 2018 seasons

	Fruit length (cm)			Fruit diameter (cm)			Fruit weight (gm)		
	Kaolin			Kaolin			Kaolin		
Irrigation levels	Untreated	5%	Mean	Untreated	5%	Mean	Untreated	5%	Mean
					First season 2017				
ETc 100 % (day after day) (control)	2.30g	2.39f	2.35D	1.69f	2.07c	1.88C	5.40g	6.17f	5.79C
ETc 80 %	2.71c	2.82a	2.77A	1.89de	2.23ab	2.06B	6.92d	8.39a	7.66A
ETc 100 %	2.59e	2.74b	2.67C	1.85e	2.19b	2.02B	6.58e	8.15b	7.37B
ETc 120 %	2.64d	2.81a	2.73B	1.98cd	2.31a	2.15A	6.81d	7.95c	7.38B
Mean	2.56B	2.69A		1.85B	2.20A		6.43B	7.67A	
					Second season 2018				
ETc 100 % (day after day) (control)	2.64e	2.70d	2.67B	1.65d	1.77c	1.71C	5.75e	6.22d	5.99C
ETc 80 %	2.55f	2.87b	2.71A	1.95b	2.21a	2.08AB	7.32c	8.46a	7.89A
ETc 100 %	2.41g	2.91a	2.66B	1.90b	2.16a	2.03B	7.15c	8.13b	7.64B
ETc 120 %	2.38h	2.79c	2.59C	1.99b	2.27a	2.13A	7.29c	8.02b	7.66B
Mean	2.50B	2.82A		1.87B	2.10A		6.88B	7.71A	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level

Table 13: Effect of kaolin spraying 5 % and different irrigation levels on seed characteristics of Picual cv. during 2017 and 2018 seasons

	Seed length (cm.)			Seed diameter (cm.)			Seed weight (gm)		
	Kaolin			Kaolin			Kaolin		
Irrigation levels	Untreated	5%	Mean	Untreated	5%	Mean	Untreated	5%	Mean
					First season 2017				
ETc 100 % (day after day) (control)	1.59d	1.60d	1.60D	0.76b	0.80ab	0.78C	0.99a	1.03a	1.01A
ETc 80 %	1.75b	1.80a	1.78B	0.88ab	0.91a	0.90AB	0.98a	0.96a	0.97A
ETc 100 %	1.67c	1.69c	1.68C	0.81ab	0.84ab	0.83BC	0.99a	1.00a	1.00A
ETc 120 %	1.79a	1.82a	1.81A	0.91a	0.92a	0.92A	1.00a	0.97a	0.99A
Mean	1.70B	1.73A		0.84A	0.87A		0.99A	0.99A	
					Second season 2018				
ETc 100 % (day after day) (control)	1.67f	1.70ef	1.69D	0.89a	1.00a	0.95A	1.00ab	1.10a	1.05A
ETc 80 %	1.78bc	1.80bc	1.79B	0.91a	0.94a	0.93A	0.94b	0.95b	0.95B
ETc 100 %	1.73de	1.76cd	1.75C	0.92a	0.96a	0.94A	0.97b	0.98b	0.98B
ETc 120 %	1.82ab	1.86a	1.84A	0.94a	0.95a	0.95A	1.02ab	1.01ab	1.02AB
Mean	1.75B	1.78A		0.92A	0.96A		0.98A	1.01A	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level

Table 14: Effect of Kaolin spray and different irrigation levels on flesh weight (g); fruit shape index and flesh/fruit (%) of Picual cv. during 2017 and 2018 seasons

	Flesh weight (g)			Flesh /fruit (%)			Flesh/seed ratio		
	Kaolin			Kaolin			Kaolin		
Irrigation levels	Untreated	5%	Mean	Untreated	5%	Mean	Untreated	5%	Mean
					First season 2017				
ETc 100 % (day after day) (control)	4.41f	5.14e	4.78C	81.67e	83.31d	82.49C	4.45d	4.99cd	4.72C
ETc 80 %	5.94c	7.43a	6.69A	85.84b	88.56a	87.20A	6.06b	7.74a	6.90A
ETc 100 %	5.59d	7.15b	6.37B	84.95c	87.73a	86.34B	5.65bc	7.15ab	6.40B
ETc 120 %	5.81cd	6.98b	6.40B	85.32bc	87.80a	86.56B	5.81b	7.20ab	6.50B
Mean	5.44B	6.68A		84.44B	86.65A		5.49B	6.77A	
					Second season 2018				
ETc 100 % (day after day) (control)	4.75e	5.12d	4.94C	82.61e	82.32e	82.46C	4.75e	4.65e	4.70C
ETc 80 %	6.38c	7.51a	6.95A	87.16bc	88.77a	87.96A	6.79b-d	7.91a	7.35A
ETc 100 %	6.18c	7.15b	6.67B	86.43cd	87.95ab	87.19B	6.37cd	7.30ab	6.83B
ETc 120 %	6.27c	7.01b	6.64B	86.01d	87.41b	86.71B	6.15d	6.94bc	6.54B
Mean	5.90B	6.70A		85.55B	86.61A		6.01B	6.70A	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level that Kaolin at 5 % with irrigation (ETc 120 %) was the highest significant values in the two seasons, respectively. While, the lowest significant value with irrigation the farm (control) during 2017 and 2018 seasons, respectively. In relation to, seed diameter and seed weight took the same line where the non significant values in both seasons, respectively.

The specific effect of different irrigation levels (80 %, 100 % and 120% from ETc L/tree daily) beside the control (irrigation farm 80 L/tree day after day) and foliar application of kaolin (0 and 5 %) on the flesh weight (g), flesh/fruit (%) and flesh/seed ratio of olive "Picual" cv., data presented in Table (14) obviously that, the foliar application of kaolin at (5 %) had the highest values of flesh weight (g) and flesh/fruit (%) than the kaolin (0.0) during both seasons of study.

With respect to the specific effect of different irrigation levels on (flesh weight (g) and flesh/fruit (%), data recorded in the same Table, mentioned that all the investigated treatments significantly increased the flesh weight (g), flesh/fruit (%) and Flesh/seed ratio of Picual cv. compared with control which was irrigation levels with "80 % ETc" per tree daily in the first and second seasons. Meanwhile, the opposite trend was detected with the which exhibited statistically the least on the flesh weight (g), flesh/fruit (%) and Flesh/seed ratio with (control) during two seasons of study.

Regarding the interaction effect of the two investigated factors i.e., the different rates of irrigation and Kaoiln foliar application on the flesh weight (g), flesh/fruit (%) and Flesh/seed ratio, data presented in the same Table clear obviously that the most simulative combination enhanced the flesh weight (g) , flesh/fruit (%) and Flesh/seed ratio of olive "Picual" cv. were that combination between kaolin (5 %) and irrigation levels with (80 %) during the two seasons. Moreover, the lowest decrease of the flesh weight (g), flesh/fruit (%) and Flesh/seed ratio was detected by (0.0) with control treatment during 2017 and 2018 seasons. On the other hand, other combinations treatments were in between in this respect. These results were showed with those obtained by Al-Khawaga [16]; El-Sayed *et al*. [67]; Saad El-Din-Ikram *et al*. [64]; Brito *et al*. [14] and Mohamed-Hoda *et al*. [30].

Fruit Content: Data reveald that and irrigation levels ETc 80, 100 and120% and the Kaolin in (1st March, April, May and June) increased significantly the fruit moisture (%) of Picual cv. compared to the control and other treatments during 2017 and 2018 seeasons respectvly.

The Kaolin folir application at 5 % in 1st March, April, May and June and irrigation daily by 80 liter/tree on Picual cv. gave the highest significant values in Fruit oil (%) during both seasons.

Dealing with the specific effect of the two investigated factors on the fruit moisture (%) and Fruit oil (%) data presented in Table (15), reflected that kaolin foliar spraying at 5 % had a higher significant value of fruit moisture (%) and fruit oil (%) than the control (0.0 %) during 2017 and 2018 seasons. Concerning different irrigation levels on moisture (%) and fruit oil (%) of Picual cv., data presented in the same Table indicated that, the highest values in the fruit moisture (%) and Fruit oil (%) were resulted by the rate of (80 %) in both seasons, whereas the opposite trend were detected with the rate of irrigate the farm (control) in both seasons, respectively. In addition to that, other treatments gave intermediate values in both seasons of study.

Regarding the interaction effect of the two investigated factors i.e., the different irrigation levels (80, 100 and 120 %) beside control (irrigation farm) and kaolin foliar application on fruit moisture (%) and Fruit oil (%), data in the same Table revealed that, Kaoiln at (5 %) x irrigation (80 %) in the first and second seasons, treatment gave the highest value of fruit moisture (%) and Fruit oil (%), On the other hand, the lowest value of fruit moisture (%) and Fruit oil (%), were detected with control during first and second seasons of study. These results were consistent with those obtained by Berenguer *et al.* [69, 70]; Herenguer *et al.,* [71; Ben-Gal *et al*. [72]; Al-Khawaga [16]; El-Sayed *et al.* [67]; Saad El-Din-Ikram *et al.* [63, 64] and Brito *et al*. [14].

Economic Study: The economic consideration comparative study of olive (Picual cv.) in 2017 & 2018 seasons that presented in Table (16) observed that, all sprayed treatments led to increase the fruit yield as compared with control. Moreover, sprayed trees with Kaolin (5 %) in 1st March, April, May and June and different irrigation levels (ETc 80 %, ETc 100 % and ETc 120 %) led to get the highest fruit yield (4200, 3840, 3660 & 3000 kg/fed) in (Picual cv.), that achieved highest gross income (33600, 30720, 29280 & 24000 EPG/Fed) which had the highest net return (19066, 15968, 14310 & 12400EPG/ Fed). On the other hand, control treatment gave the lowest net return (565 EPG/Fed) in (Picual cv.) respectively. So we can conclude that, spraying Kaolin (5 %) in 1st March, April, May and June and irrigation level (ETc 80 %) is preferable for getting higher profit as comparing with other treatments.

Table 15: Effect of Kaolin spraying 5% and different irrigation levels on fruit chemical content of Picual cv., during 2017 and 2018 seasons

	Fruit oil (%)			Fruit moisture (%)		
	Kaolin			Kaolin		
Irrigation levels	Untreated	5%	Mean	Untreated	5%	Mean
First season 2017						
ETc 100 % (day after day) (control)	38.40e	40.65d	39.53D	66.90f	68.22c-e	67.56C
ETc 80 %	44.15b	45.64a	44.90A	68.44b-d	69.47a	68.96A
ETc 100 %	42.88c	43.64bc	43.26B	67.92de	69.12ab	68.52AB
ETc 120 %	40.90d	41.40d	41.15C	67.49ef	68.96a-c	68.23B
Mean	41.58B	42.83A		67.69B	68.94A	
Second season 2018						
ETc 100 % (day after day) (control)	43.23e	44.75d	43.99D	66.60e	67.83cd	67.22C
ETc 80 %	46.80b	48.15a	47.48A	67.96cd	69.70a	68.83A
ETc 100 %	45.36cd	46.78b	46.07B	68.30bc	69.81a	69.06A
ETc 120 %	44.68d	45.92c	45.30C	67.20de	68.96b	68.08B
Mean	45.02B	46.40A		67.52B	69.08A	

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% level

Table 16: Economic study of Picual cv. olive trees that sprayed and different irrigation levels with average two seasons (2017 and 2018)

Treatments		Average yield (Picual cv.) (kg/Fed)	Price/ 1 kg (EGP)	Gross income (Picual cv.)	Total cost of treatments (EPG/Fed) Fixed cost	Spraying Kaolin	Irrigation M^3	Price/ 1 EGP/$1M^3$)	Total	Average net return of (Picual cv.) (EPG/Fed)
Treatment without Kaolin	ETc 100 % (day after day) (control)	1800	8	14400	10000	0.00	3835	3835	13835	565
	ETc 80 %	2945	8	23563	10000	0.00	3079	3079	13079	10484
	ETc 100 %	2765	8	22123	10000	0.00	3311	3311	13311	8812
	ETc 120 %	2557	8	20458	10000	0.00	3544	3544	13544	6914
Treatment with Kaolin (5 %)	ETc 100 % (day after day) (control)	3000	8	24000	10000	1600	3835	3835	11600	12400
	ETc 80 %	4200	8	33600	10000	1600	2934	2934	14534	19066
	ETc 100 %	3840	8	30720	10000	1600	3152	3152	14752	15968
	ETc 120 %	3660	8	29280	10000	1600	3370	3370	14970	14310

CONCLUSSION

This research can recommend the application of Kaolin at 5 % in 1st March, April, May and June and irrigation level ETc 80% (2934-3079 m^3 fed/year) for improving perfect flowers (%), fruit set /m, number of remained fruits (m), fruit weight, yield (kg/tree), gave the lowest fruit drop (%) and gave the highest significant values in fruit oil (%) and net return during both seasons.

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