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Olive Oil Quantity and Quality as Affected by Different Irrigation Water and N-Fertilization treatments

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Abstract: A field experiment was conducted in the experimental station of National Research Centre in El-Nobaria area, Egypt, during two successive seasons 2012 and 2013 to investigate the effect of using various ratios from ammonium sulphate (as mineral nitrogen fertilizer) and farmyard–manure (as organic fertilizer) under three different rats of irrigation water requirements on olive oil yield and quality of two olive cultivars, Kronaki (as oil production) and Picual (as dual purpose) under drip irrigation system. Five fertilization treatments were used, 100% ammonium sulphate (F_1), 75% N_2SO_4 +25% FYM (F_2), 50% N_2SO_4+50% FYM (F_3), 25% N_2SO_4+75% FYM (F_4) and 100% FYM (F_5) were combined with three levels of irrigation water 100%, 66% and 33% of ETc . The obtained results revealed that, the treatment of 66% ETc combined with 50% mineral nitrogen fertilizer + 50% FYM gave the highest oil yield of the two cultivars.

Free acidity and peroxide value gradually decreased by increasing the ratio of organic fertilizer in all fertilization treatments. While the UV absorbance values of K232 don't significantly affected by irrigation and fertilization treatments, the values of K270 increased by increasing the amount of ETc and FYM.

Keywords: Olive Oil, Irrigation Water and N- Fertilization treatments.

Introduction

Olive trees (*Oleaeuropaea* L.) is one of the most important and a widely distributed trees grown in many arid and semi-arid regions of the world[1,2,3]. The production of olive in these areas is generally low due to the poor soil fertility, low rainfall and low water holding capacity[4,5]. It is considered a national treasure of wealth compared with the others. Olive fruits and oil yield characterized by high nutrition value and medical importance [6].

In Egypt, according to the latest statistics of the Egyptian Ministry of Agriculture in 2012 the total cultivated land with olive was 202,743 fed., about 14,353 fed., of this area in the old land and 188,390 fed. in the new land.The total production was 563,070 T, 760,17 T in the old land while 487,053 T in the new land[7].

Irrigation requirements for olive trees in arid regions ranged from 600 to 1000 mm[8]. Egypt facing water crisis since the water consumption per person is below the water poverty (1000 m^3 per person/year). The drip

irrigation system can be used to insure lowering lose water and good distribution of soil moisture in the root zone depth without raising the soil moisture.

Increasing olive fruit yield depending on the amount of irrigation water [9,10]. Yield of Kronaki olive cultivar significantly higher than Toffahi and Picual cultivar[11]. Pierantozzi *et al.*[12] concluded that, fruit yield of Arbequina cultivars more than Manzanillo .

Patumi *et al*[13] pointed out that, free acidity and peroxide values of olive oil were not affected by different irrigation treatments**.** Wahbi *et al.*[14]examined the effects of four irrigation treatments on olive oil quality and they found that, there were no significant differences on oil yield and oil acidity between all treatments. Gómez-Rico *et al.*[15]concluded that, free acidity and the peroxide value don't affected by irrigation water treatments during the first season and they added that, these parameters significantly increased during the second year. Moreover, the UV absorbance at 232 and 270 nm, significantly affected also in the second season only .

This investigation aimed to study the effect of substitution of chemical nitrogen fertilizers with FYM fertilizer under different irrigation water levels on olive oil productivity and quality.

Materials and Methods

A field experiment was conducted during two successive seasons 2012 and 2013 at agricultural experimental station of the National Research Centre, at El-Nobaria area. The experimental soil was classified as sandy soil in texture, which having pH:8.8, EC: 0.4 dSm^{-1},OM:0.21%,$CaCO_3$:7.4%. Two olive cultivars *Oleaeuropaea* L.cvs. (Picual as Dual Purpose and Kronaki as olive oil production) were used. The trees were 6-years-old with planting distances of 5×5 m. (168 tree per Fed.), which irrigated with drip irrigation. The drip irrigation network consisted of two laterals for every row of trees. The laterals were situated 50cm from the trunk on both sides of the tree. Six online emitters were devoted for each tree (3 emiters on each side). The emiters discharge was 8 L/h.

The experimental design included three irrigation treatments:100% of estimated crop evapotranspiration in mm/ day (ETc.) as control, 66% and 33%, of ETc. irrigation was carried out according to the methodology proposed by [16]. Five N fertilization treatments were applied as follows: chemical fertilizers 100% (F_1), 75% chemical fertilizers + 25% organic fertilizers (F_2), 50% chemical fertilizers +50% organic fertilizers (F_3), 25% chemical fertilizers +75% organic fertilizers (F_4) and 100% organic fertilizers (F_5). Organic amendments application rates dependent on its total N content (1.14%) of the farmyard manure. The recommended doses of fertilizers for olive trees age 6 years according to the recommendations of Ministry of Agriculture are ; 4 Kg ammonium sulphate 20 %N + 2 kg potassium sulphate 50% K_2O +1.5 Kg mono supper phosphate 15.5% P_2O_5 per tree/ year . The fertilization treatments, ammonium sulphate and farmyard manure fertilizers or their mixtures were added in two equal portions, the first portion at middle of April and the other later at middle of August. The experiment included 15 separate treatments (5 fertilization and 3 irrigation) for every cultivar, in completely randomized block design with four replicates.

At ripening stage, olive fruits samples were hand-picked for determination the oil content, and the yield of each tree were recorded as Kg/ tree. After harvesting, the olive fruit samples were placed in perforated plastic boxes and transported at the same day to the laboratory.

Fruit oil content and quality:-

Oil extraction process, and oil chemical determination going on immediately after the arrival of the olives to laboratory. Fruit oil content was determined from fruit dry weight according to method by extraction the oil from the fruit with Soxhelt using petroleum ether 60-80 C^o of boiling point[17],the oil yield as Kg/tree was recorded.

For determination the oil quality, about 2-3 Kg from olive fruits were cleaned, crushed with a hammer crusher and the paste pressed by a Carver piston (Model s/n 37000-152- fred S- carver INC P.O. Box544, WABASH, in USA46992-0544 product U.S and Foreign patents.) the oil transferred into dark glass bottles for determination the following parameters of oil quality:-

a) Free acidity (acid value) :- It was determined according to[18].
b) Peroxide value:-The peroxide value was determined according to [19] Peroxide value, expressed as meq. O_2 kg^{-1} of oil, which calculated according to the following equation:

Peroxide value = 0.5 x N x V x100 /weight of sample
Where :-
N = normality of sodium thiosulphate solution.
V = volume in ml. of Sod. Thiosulphate needed for equilibrium point.

c) UV absorption:-

The ultraviolet absorbance at 232 nm (conjugated diene) and at 270 nm (conjugated triene) of the oil samples were measured on Spectrophotometer [20].

Data were subjected to statistical analysis through analysis of variance ANOVA [21].

Results and discussion

1- Oil quantity

Data presented in table (1) show that, 50 % organic fertilizer combined with 50% ammonium sulphate (F_3) record the highest oil content compared with the other treatments, these values decreased with increasing the rate of organic or chemical fertilizers. This results are agreement with those of Abou El- khashab *et al*. [22] who revealed that, oil content of Kronaki cultivar increased by using a mixture of organic farmyard manure + compost+ bio-fertilizers. [23] concluded that, higher oil content was obtained under supplemental fertilization treatments than control. While [24] pointed out that , increasing nitrogen fertilization (0.00, 0.25, 0.50 and 1.00 Kg N / tree) improved the oil content of Picholine cultivar 35 years old, however the oil content of Moroccan 9 years old and Arbequina 7 years old, was negatively affected.

Data also show that, oil content register the highest values under 66% irrigation treatment (18.00 gm oil /100 Kg fruit) while the lowest recorded at I_3 (14.47 gm oil/100gm fruit), Such results are in harmony with Dabbou *et al.*[25] indicated that, increasing the amount of irrigation water from 50% to 75% and 100% of ETc positively affected the fruit oil content of Arbequina olive cultivar, Pierantozzi *et al.*[12] concluded that, increasing the amount of irrigation water treatments as (0, 25, 50 75% and 100% from ETc) on Arbequina and Manzanillo olive cultivars raised the oil content (gm/Kg. fruit). On the contrary,[10,26] noticed that, irrigation treatments had no effect on olive oil content.

Data show that, Kronaki olive cultivar give high oil content value 17.5 gm/100gm fruits compared with Picual 15.75 gm/100gm fruits .These results are quite agreement with the finding of [11] reported that, Kronaki olive cultivar had higher oil content than Picual cultivar, [12] added that, the oil content of Arbequina cultivar was more than Manzanillo olive cultivar.

Table (1). Effect of irrigation and fertilization treatments on oil content (gm/100 gm fruits) of the two olive cultivars

Cultivars (Cv)	Fertilizers (F)	Irrigation (I)			Mean
		100%	66%	33%	
Kronaki	F1	17.3	18.2	15.1	**16.87**
	F2	18.9	19.5	15.8	**18.07**
	F3	19.55	19.8	16.3	**18.55**
	F4	18	19	15.5	**17.50**
	F5	17	18.3	14.3	**16.53**
Mean		**18.15**	**18.96**	**15.4**	**17.50**
Picual	F1	16.8	16.2	13.6	**15.53**
	F2	17	17.4	13.1	**15.83**
	F3	17.6	17.9	14.4	**16.63**
	F4	16.4	17.1	13.6	**15.70**
	F5	15.5	16.6	13.00	**15.03**
Mean		**16.66**	**17.04**	**13.54**	**15.75**
	F1	17.05	17.20	14.35	**16.20**
	F2	17.95	18.45	14.45	**16.95**
	F3	18.58	18.85	15.35	**17.59**
	F4	17.2	18.05	14.55	**16.60**
	F5	16.25	17.45	13.65	**15.78**
Irrigation mean		**17.41**	**18.00**	**14.47**	
LSD 0.05	**I**=0.033	**F**= ns	**Cv.**= 0.17	**I*F**=0.045	
	I*Cv= 0.032	**F*Cv**=0.039	**I*F*Cv**= 0.067		

Concerning the combined effect between the irrigation and fertilization treatments on oil content,the lowest oil content (13.65 gm/100gm fruit) record at F_5I_3 treatment, while the highest oil content is find under F_3I_2 treatment (18.85 gm/100gm fruit). Data indicate a significant effect of the interaction between irrigation and fertilization treatments on oil yield. These results are confirmed by the finding of Toplu *et al.*[23]who found that, total oil yield of olive increased about three times under the highest irrigation water and fertilization treatments compared to rain-fed and unfertilized trees.

2- Oil quality

Free fatty acid plays an important role in the flavor characteristics and formation of organoleptic toxic compounds that reduce the nutritional value of the olive oil and its market value.

A. Acid value

Acid value given as percent of oleic acid per 100gm oil. Data in table (2) representing the effect of irrigation treatments on acid value, the acid values slightly decreased as a result of reducing the irrigation water levels. I_3 (33% of ETc) record the lowest acid value (0.178) while irrigation treatment I_1 (100% of ETc) register the highest one (0.246), . These results are in harmony with ,[28] they revealed that, irrigation of 100 of ETc increased oil acidity of Gemlik olive compared with rain-fed condition**.** , Caruso *et al.*[27] stated that, the lowest free acidity values of Frantoio olive cultivar were recorded in oils, which obtained from severely stressed water trees. On the other hand, [28] concluded that, olive oil acidity was not influenced by the amount of irrigation water.

Table (2). Effect of irrigation and fertilization treatments on acid value(gm oleic acid/100gm oil) of the two olive cultivars.

Cultivars (Cv)	Fertilizers (F)	Irrigation (I)			Mean
		100%	66%	33%	
Kronaki	F1	0.278	0.205	0.203	**0.229**
	F2	0.277	0.206	0.179	**0.221**
	F3	0.234	0.170	0.165	**0.190**
	F4	0.222	0.166	0.165	**0.184**
	F5	0.204	0.137	0.164	**0.168**
Mean		**0.243**	**0.177**	**0.175**	**0.198**
Picual	F1	0.378	0.355	0.356	**0.363**
	F2	0.309	0.233	0.165	**0.236**
	F3	0.229	0.196	0.145	**0.190**
	F4	0.205	0.172	0.118	**0.165**
	F5	0.124	0.124	0.119	**0.122**
Mean		**0.249**	**0.216**	**0.181**	**0.215**
	F1	0.328	0.280	0.280	**0.296**
	F2	0.293	0.220	0.172	**0.228**
	F3	0.232	0.183	0.155	**0.190**
	F4	0.214	0.169	0.142	**0.175**
	F5	0.164	0.131	0.142	**0.145**
Grand mean		**0.246**	**0.196**	**0.178**	
L.S.D 0.05	**I** = ns	**F**= 0.003	**Cv.**= ns	**I*F**= 0.006	
	I*Cv=ns	**F*Cv**=0.007	**I*F*Cv**=0.012		

Data show that, increasing substitution of organic fertilizers instead of chemical fertilizers caused a decreasing of acid value of olive oil. It record 0.296, 0.228, 0.190, 0.175 and 0.145 for fertilization treatments of F_1, F_2, F_3, F_4 and F_5 , respectively. Fernández-Hernández *et al.*[29]revealed that, the oil acidity parameters of Picual olive cultivar were mostly affected by compost addition as compared to mineral fertilization**.** Moreover, [30]pointed out that, excessive oil acidity was strongly associated with low fruit load and high N concentration in fruits. Oil acidity was significantly affected by different mineral nitrogen fertilization individual or combined with bio-fertilization treatments[5].

The data reveala small increase in acid value of Picual cultivar (0.215%) compared with Kronaki cultivar (0.198%) . Samra *et al.* [11]pointed out that, Picual olive cultivar gave higher values of oil acidity than Kronaki olive cultivar in both seasons.

Concerning the interaction effect between irrigation and fertilization treatments on acid value, increasing substitution of organic fertilizer instead of chemical fertilizers decreased free acidity under all irrigation treatments. Generally irrigation level I_1 give high acid value compared with the other irrigation treatments, F_1 I_1give the highest value (0.328), while F_5I_2 give the lowest one (0.131) . Oil acidity of Gemlik olive cultivar significantly affected as a result of the combination between irrigation and fertilization treatments, and the addition of more irrigation water increased acid value of olive oil [23].

B. Peroxide value

Peroxide value given as meq. of active O_2/ Kg oil. The data illustrate in Fig.(1) show that, peroxide values slightly decreased with reducing the irrigation water levels . There are 4.425, 4.316 and 3.988 meq O_2/Kg oil at the irrigation treatments of I_1, I_2 and I_3, respectively., and no significant effect of various irrigation treatments is obtained on peroxide value. Motilva *et al.*[31,32] demonstrated that, there were no significant differences of peroxide value throughout the irrigation treatments. Peroxide value of the irrigated

trees was higher than that from non-irrigated trees[33].Caruso *et al*. [27] revealed that, peroxide value of Frantoio olive cultivar decreased as the degree of water deficit increased.

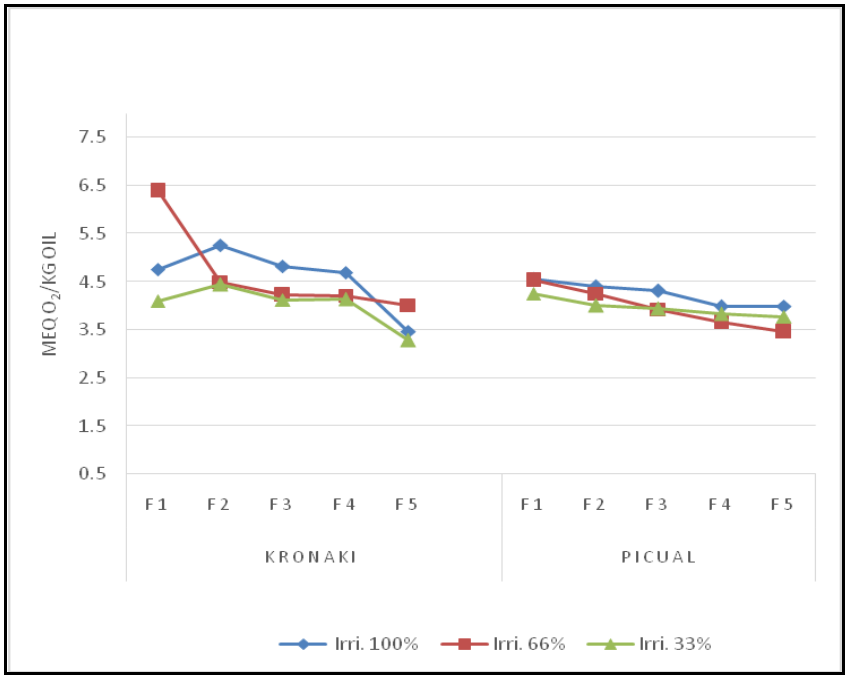

Fig.(1) Effect of irrigation and fertilization treatments on peroxide valueof the two olive cultivars.

Data show also that, increasing the partial replacement of chemical fertilizers by organic fertilizers significantly decreased peroxide values in olive oil. The mean values are 4.761, 4.476, 4.224, 4.086 and 3.666 meq.O_2/Kg oil under the fertilization treatments of F_1,F_2, F_3, F_4 and F_5, respectively, These results are confirmed by El–Sharony[34]who revealed that, the highest peroxide value was observed at 100% mineral fertilization treatment. On the other hand, Fayed[35] revealed that, application of camel manure gave the highest peroxide values in all cultivars under study.

Statistical analysis failed to detect significant variation between the two olive cultivars for peroxide value

C.- UV absorption

1) K232:-

Data representing the effect of irrigation treatmentson K232 are listed in table, (3). The mean values of two seasons slightly decreased by reducing the irrigation water treatment, it was 2.344, 2.227, and 2.135 under the irrigation treatments of I_1, I_2, and I_3, respectively. These results are in agreement with Berenguer *et al.*[36] concluded that, K 232 values were affected by irrigation only in the treatments which received the lowest water volumes .The values of K232, were lower in the rain-fed treatment compared with the other irrigated treatments on olive trees[37].

Table (3).Effect of irrigation and fertilization treatments on K232 of the two olive cultivars.

Cultivars (Cv)	Fertilizers (F)	Irrigation (I)			Mean
		100%	66%	33%	
Kronaki	F1	2.400	2.365	2.437	**2.401**
	F2	2.398	2.264	2.162	**2.275**
	F3	2.384	2.427	2.227	**2.346**
	F4	2.447	2.442	2.228	**2.372**
	F5	2.444	2.436	2.331	**2.404**
Mean		**2.415**	**2.387**	**2.277**	**2.359**
Picual	F1	2.257	2.052	1.964	**2.091**
	F2	2.063	1.970	1.737	**1.923**
	F3	2.253	1.873	2.066	**2.064**
	F4	2.380	2.194	1.939	**2.171**
	F5	2.418	2.354	2.260	**2.344**
Mean		**2.274**	**2.089**	**1.993**	**2.119**
	F1	2.329	2.209	2.201	**2.246**
	F2	2.231	2.117	1.950	**2.099**
	F3	2.319	2.150	2.147	**2.205**
	F4	2.414	2.318	2.084	**2.272**
	F5	2.431	2.342	2.296	**2.356**
Grand mean		**2.344**	**2.227**	**2.135**	
L.S.D 0.05	**I** = ns **F**=ns **Cv.**= ns **I*F**=ns **I*Cv**=ns **F*Cv=ns** **I*F*Cv**=ns				

Concerning the effect of fertilization treatments on K232 of olive oil (irrespective of cultivars and various irrigation water levels), the data presented in table (3) reveal that, the organic fertilization treatment raised K232 compared with chemical fertilizers but there is no significant variation could be detected between treatments. This finding confirmed by Fernández-Hernández *et al*. [29]who found that, K232 of Picual olive cultivar were mostly affected by the harvesting and extraction procedures rather than the cultivation techniques. Also, no significant differences among chemical and organic fertilization treatments were found about their effect on K232 of Leccino and Frantoio olive cultivars[38].

Concerning the effect of fertilization treatments on K232 of olive oil (irrespective of cultivars and various irrigation water levels), the data presented in table (3) reveal that, the organic fertilization treatment raised K232 compared with chemical fertilizers but there is no significant variation could be detected between treatments. This finding is confirmed by Fernández-Hernández *et al*. [29]who found that, K232 of Picual olive cultivar was mostly affected by the harvesting and extraction procedures rather than the cultivation techniques. Also, Rosati *et al.*[38] added that, no significant differences among chemical and organic fertilization treatments were found about their effect on K232 of Leccino and Frantoio olive cultivars.

Data in table (3) show the interaction effect between irrigation and fertilization treatments on K 232, under all irrigation treatments, the fertilization treatment F_5 give the highest values, there are 2.431, 2.342 and 2.296 for F_5I_1, F_5I_2 and F_5I_3 respectively, while the fertilization treatment F_2 record the lowest K232 under all irrigation treatments.

2) K270

With regard to the irrigation water treatments on K270, data illustrate in Fig. (2) show that, the highest K270 value is record at irrigation level I_1while I_3 regester the lowest one. There are 0.253, 0.242 and 0.189 under the irrigation treatments of I_1, I_2 and I_3, respectively.

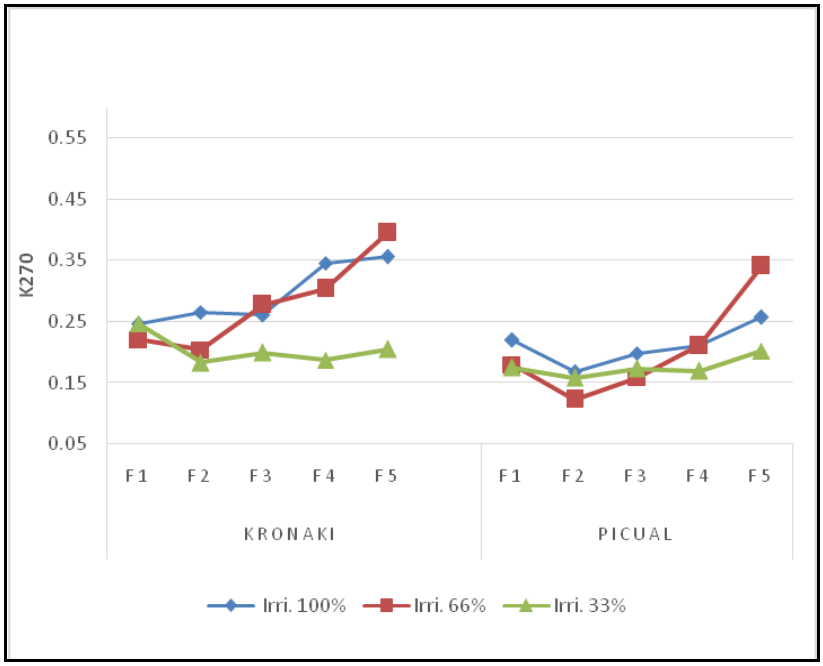

Fig. (2) Effect of irrigation and fertilization treatments on K270 of the two olive cultivars.

These results are quite agreeable with finding of Berenguer *et al.*[36], who found that, K270 Values were negatively affected by irrigation only at the treatments which received the lowest irrigation water levels. Moreover, irrigation water regime had slightly effected on K270 of Arbequina olive cultivar[25]. On the contrary, Morales-Sillero *et al.*[39]revealed that, K 270 nm, usually showed a significant decreasing trend with increasing the water supply.

Data show also that, the highest K270 value record at fertilization treatment of F_5 (0.293), while the lowest at F_2 (0.183). In case of the effect of cultivars on K270 the data revealed that, kronaki olive cultivars give high K270 (0.260) compared with Picual olive cultivar (0.196).

The interaction effect between irrigation and fertilization treatments on K270.Generally, the treatment of (100%) organic fertilizer under different irrigation treatments give the highest K270 compared with the other treatments. There are 0.307, 0.368 and 0.204 under the irrigation treatments of I_1, I_2 and I_3respectively. The treatment of F_2I_2 give the lowest K270 value 0.164 while F_5I_2 give the highest value 0.368 .

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