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Effect of magnetic saline irrigation water and soil amendments on growth and productivity of Kalamata olive cultivar

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Abstract

The field experiment was conducted at Al-Salam International for Development and Agricultural Investment private farm at 64 Kilometer (Cairo- Alexandria Desert Road), Egypt to study the effect of magnetic saline irrigation water (MW) and soil amendments; magnetic iron (MI) and Nile fertile (NF); on vegetative growth, fruit characteristics, nutrients statues in leaves, fruits and some soil properties, besides proline content in the leaves and fruits of Kalamata olive trees under soil salinity of 3430 ppm and water salinity of 3904 ppm during two successive seasons (2016-2017 and 2017-2018), and productivity at three seasons (2016-2017 / 2017-2018 and 2018-2019). The results showed that, MW and MI+NF enhanced vegetative growth significantly (shoot length, leaf density and leaf surface area), number of fruits/shoot, total yield/tree and fruit physical characteristics, as well as macro and micro nutrients content in leaves, fruits and soil during 1st and 2nd seasons. Proline content of leaves and fruits decreased in all treatments received (MW) compared to those of non magnetic saline irrigation (NMW). These results performed that, the soil irrigated with MW and amended with MI and Nile fertile achieved net income of about 36362.5 LE fed^{-1} (average tow growing seasons 2017 and 2018) for the olive grower in comparison with other treatments. It could be recommended to use MW and fertilization with MI (500 g/tree) +NF (2 kg/tree/year) under 3430 ppm soil salinity of and 3904 ppm water salinity to decrease salinity and enhance vegetative growth, yield characteristics and increase net income of Kalamata olive trees.

Keywords: Olive, Magnetic water, Nile fertile, Magnetic iron, Soil salinity, Productivity, Proline and nutrient status and Soil properties.

INTRODUCTION

The olive tree resists the harsh environmental conditions of most Mediterranean countries (Fernández, 2014). In spite of the fact that it is considered a profoundly strong and tolerant trim to a few abiotic stresses, olive growing regions are usually affected by adverse environmental factors, water scarcity, heat and high soil salinity and are especially vulnerable to climate change, which cause water depletion in cells, are responsible for a large proportion of losses in productivity (Bose *et al.,* 2014; Pandolfi *et al.,* 2017; Brito *et al.,* 2019). In Egypt olive cultivation increased continuously and reached 250000 Feddan which produce 600000 ton, most of them are table olive (Statistics of Ministry of Agriculture and Land Reclamation, 2017).

Soil and water salinity effects on yield depend on the concentration but even though tolerance is a cultivar dependent characteristic. Olive trees are less sensitive to leaf Cl^- than Na^+. Calcium plays an important role in Na^+ exclusion and retention mechanisms (Fernández-Escobar *et al.,* 2013).

The importance of physical treatment of saline water using magnetic devices become feasible. Magnetic water (MW) is considered as environmentally friendly technique (Nimmi and Medhu, 2009). MW is produced when water passes through the magnetic field of magnetic permanent device or electromagnetic one, installed on feed pipeline, where all water and salt molecules have internal vibration (Babu, 2010). In general, there are three primary watched impacts of MW in soil 1- the removal of excess soluble salts, 2- bringing down of pH esteems, and 3- the dissolving of slightly soluble components such as phosphates, carbonates and sulphates. Moreover, the attractive strategy of magnetic method for saline water is allegedly a successful technique for soil desalinization (Mostafazadeh *et al.,* 2011). The magnetic technique assists with amassing nutrients in the plant leaves because some of the nutrients such as Mg, S and Fe are magnetic. They are pulled in to the magnetic field and concentrate in the leaves that are in direct contact of that field (Carrera, 2009). However, Magnetic fields may assume a significant action in cation take-up and positively effects on immobile plant nutrient uptake (Esitken and Turan, 2003).

Magnetic iron (MI) is one of the most important factors affecting plant growth and it is a very high iron content of natural row rock (Mansour, 2007). The addition of the natural magnetic iron could improve soil structure, organic matter, water properties, cation exchange capacity and become more energy and vigour which is known as "Magneto biology" that helps plant growth, moderation of soil temperature, improved water holding capacity and crop nutrition. Besides, the magnetic instrument isolates all chlorine, unsafe gases from soil, which expanded salt development and dissolvability of nutrients (Ismail *et al*., 2010). The interaction effect of magnetic iron (MI) and potassium humate recorded the highest values of flowering and productivity of Aggizi olive trees (Abo-Gabien *et al.*, 2020). Magnetic iron increased significantly vegetative growth and yield of pepper plant under saline irrigation water (Taha *et al.*, 2011), increased leaf mineral content of cauliflower (Mansour, 2007), and it was suggested that using compost and magnetic iron (300 kg fed^{-1}) improved vegetative growth and yield production of cucumber plants (Shehata *et al.*, 2012).

Thiobacillus spp. bacteria, considered the most important microorganisms, helps to oxidize Nile fertile (NF) involved in the bioleaching of sulphide compounds to sulphuric acid in amount enough to decrease soil PH, improve availability of most nutrients in soil and uptake by plants, enhancing and increasing root development and activity of soil microorganisms (Kassem *et al.*, 1995). Application of NF on Black Monukka grapevines (Rizk-Alla and Tolba 2010) and Le Conte pear trees (Soliman and Aaid 2016) significantly increased leaf mineral contents (N, P and K) comparing with untreated trees. Atawia *et al.*, 2017, found that Valencia orange trees received K-silicate + NF + MI as such treatments enhanced vegetative growth and leaf physical characteristics as well as minimized leaf osmotic pressure.

The objective of this study was to determine the effects of magnetic saline irrigation water and soil amendments on nutrients statues and productivity of Kalamata olive trees under water and soil salinity conditions and whether MW could reduce the effect of salts accumulation in root zone soil.

MATERIALS AND METHODS

Field experiments were carried out in Al-Salam International for Development and Agricultural Investment private farm at 64 Kilometer from Cairo Alexandria Desert Road; situated at 30° 268` 215`` N latitude, 30° 806` 534`` E longitude, during two successive seasons (2016-2017 and 2017-2018) to investigate the effect of magnetic saline irrigation water and soil amendments on vegetative growth, productivity and nutrients statues of Kalamata olive trees and soil properties, and productivity at three seasons (2016-2017 / 2017-2018 and 2018-2019).

Plant materials and agricultural practices:

The chosed Kalamata olive trees cv. were about 9 years old originated from vegetative propagation. The trees were planted at 6×4 meter apart (150 Kalamata olive trees/fed + 25 Picual olive trees cv./fed as pollinizer), irrigated with drip irrigation system with the same amount of water (2400 m^3/fed./season), under drip irrigation system, 12 drippers $tree^{-1}$ with discharge of 4 liters $hour^{-1}$ (GR tube). The Kalamata olive trees were subjected to the regularly recommended agricultural practices during the three years of study according to The Ministry of Agriculture. Olive trees were fertilized with the recommended doses of "67, 36, 77, 15, 9 and 2 unit fed^{-1}" for N, P, K, Mg, Ca and B, respectively. Mineral fertilizers were added (including control) in the forms of ammonium sulphate (20.6% N), mono calcium superphosphate (15% P_2O_5) and phosphoric acid (80%), potassium sulphate (52% K_2O), magnesium sulphate (16% MgO), calcium nitrate (15% N) and borax (11% B). Full doses of mono calcium superphosphate and 50% of N, K and Ca fertilizers were applied to soil during winter management in an organic form at rate of 20 kg compost/tree/year, and the remaining one were added as mineral form through the fertigation program all over the season.

Experimental plots were arranged in a split-plot design with three replicates. The main plots represent the type of water; non-magnetic water (NMW) and magnetic water (MW). The sub-plots were derived to four groups of amendments; magnetic iron (MI), Nile fertile (NF), and their mixture (MI+NF) plus autogenic control (Untreated). The number of treatments were eight and arranged as the following:-

Irrigation with NMW		Irrigation with MW	
T1	Autogenic control (Untreated).	T5	Autogenic control (Untreated).
T2	Magnetic iron (MI)*.	T6	Magnetic iron (MI).
T3	Nile fertile (NF)**.	T7	Nile fertile (NF).
T4	Mixture of MI+NF.	T8	Mixture of MI+NF.

*Magnetic Iron is a natural row rock has high iron content (%). ** "Nile Fertile is a bio-mineral sulfur fertilizer.

Irrigation water source was magnetized by passing magnetic field Magnolith (EWL umelttechnick GMBH, German) permanent magnets with north and south poles 88 cascaded magnetic field. The strength of this magnetic field ranged between 2000-4000 Gauss. The device consists of two parts, attached to an irrigation pipe with its internal diameter of 3 inches.

Magnetic iron was added at a rate of 500 g $tree^{-1}$ in the first and third season only (every two years), whereas Nile fertile was added at a rate of 2kg $tree^{-1}$ during winter management by mixing with soil in wetting zone adhesive to the roots in all seasons, while the treatment of their mixture (MI+NF) at the same rates (500g + 2kg), respectively in 2017 - 2019 growing seasons.

Fertilization program started at first of January to 15 November 2017 and 2018 growing seasons. The trees was irrigated twice a week during the months of January, February, November and December, while during March, April, September, and October it was irrigated three times, and six times a week during the months of May, June, July and August.

Samples from surface soil (0-30 cm), water and olive leaves and fruits were collected from all treatments. Soil samples were air-dried, grounded to pass through a 2.0 mm sieve and thoroughly mixed. Physical and chemical properties of the soil were determined and the results are given in Table (1). Chemical analysis of non-magnetic and magnetic water are presented in Table (2). Magnetic iron, Nile fertile and compost samples were analysed for various physio-chemical properties using standard methods, and were summarized in Tables (3 and 4).

Table (1): Physical and chemical properties of the studied soil.

pH*	**EC ****	**Soluble cations (meq L^{-1})**				**Soluble anions (meq L^{-1})**				**ESP**
(1: 2.5)	**(dS m^{-1})**	**Ca**	**Mg**	**Na**	**K**	**CO_3**	**HCO_3**	**Cl**	**SO_4**	
7.99	5.35	21.10	8.30	20.40	2.20	ND***	3.10	39.60	9.30	7.17

*(soil water suspension) ** (soil paste) ***ND= not detected

Coarse Sand %	**Fine Sand %**	**Silt %**	**Clay %**	**Texture class**	**$CaCO_3$ %**	**OM %**	**Plant available nutrient (mg kg^{-1})** N	P	K	Fe	Mn	Zn	Cu	B
29.70	32.70	14.20	23.40	Sandy clay loam	3.21	0.93	148	88.25	22.51	11.34	14.89	8.26	11.20	0.88

Table (2): Chemical analysis of water used in the experiment.

Water type	**pH***	**EC dS m^{-1}**	**Soluble cations (meq L^{-1})** Ca	Mg	Na	K	**Soluble anions (meq L^{-1})** CO_3	HCO_3	Cl	SO_4	**SAR**
Non-magnetic water	7.15	6.10	22.69	16.54	16.54	0.17	ND	1.52	18.75	47.91	6.56
Magnetic water	7.15	6.07	21.66	18.25	28.17	0.19	ND	1.71	18.47	48.08	6.42

	Macro nutrients (mg L^{-1})			**micro nutrients (mg L^{-1})**				
	NH_4^+	**NO_3**	**P**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
Non-magnetic water	2.35	15.49	0.03	0.05	0.12	0.03	0.01	1.22
Magnetic water	1.89	17.55	0.02	0.05	0.12	0.03	0.01	1.20

ND= not detected

Table (3): Chemical characteristics of magnetic iron and Nile fertile.

	N %	**P_2O_5 %**	**K_2O %**	**Fe_3O_4 %**	**MnO %**	**MgO %**	**S %**	**CaO mg kg^{-1}**	**Zn mg kg^{-1}**	**Cu mg kg^{-1}**	**B mg kg^{-1}**
Magnetic iron	ND	0.05	ND	41.98	0.27	0.84	ND	1.27	317.27	49.80	142.85
Nile fertile	2.3	3.5	0.5	1.54	0.029	1.5	30	5	33.97	14.82	35.50

ND= not detected

Table (4): Physical and chemical analysis of the used compost

	Bulk density	Moisture	pH (1:10)	EC (1:10)	Total N	NH_4^+	NO_3^-	OM	OC	Ash	C/N ratio	P_2O_5	K_2O
Unit	kg m^{-3}	%			%	mg kg^{-1}	mg kg^{-1}	%	%	%		%	%
value	705	32	8.2	2.45	1.20	256	142	31.5	18	68	15:1	0.65	0.85

The following measurements and determinations were carried out of the two growing seasons (2016-2017 / 2017-2018):

Vegetative growth parameters: Shoot length (cm), leaf density m^{-1} (number of leaves/shoot length×100) and leaf surface area (cm^2): Samples of approximately 40 adult leaves were taken from the middle portion of selected shoots at the mid of July for the determination of average leaf surface area according to Ahmed and Morsy, (1999) using the following equation: Leaf area = 0.53 (length ×width) +1.66

Fruiting and total yield/tree: Fruits no/shoot in 2016-2017 and 2017-2018 seasons, due to the phenomena of alternate bearing the parameter of total yield/tree of third year were assessed in 2018-2019 season: the olive fruit were harvested at the end of September; at maturity (olive with superficial pigmentation on more that 50% of the exo-carp) and the average yield was calculated (kg $tree^{-1}$) for each treatment as well as fruit physical properties: Ten fruits from each treatment at maturity has been described and identified by morphology description of Cimato and Attilio (2008). Average fruit weight (g), fruit length and width (cm) and flesh/fruit weight (%) were determined.

Chemical analysis of leaves and fruits: The sample of leaves taken in July, washed with tap water followed by distilled water, then put in an oven and dried at 70 ^oC till the stable weight, then grounded in stainless steel mill. Half gram of dry matter was wet digested as well as olive fruit digested in fresh weight using a mixture of sulphuric and percloric acids ($HClO_4$+H_2SO_4) according to the procedure of Benton and Jones (2001).

Soil experimental analysis: Particle size distribution was carried out using the pipette method; calcium carbonate was determined using the calcimeter method and organic matter content was determined using Walkley and Black method, as described by ICARDA (2013). Electrical conductivity (EC) in water and soil paste extract was dictated by Electrical Conductivity meter (model WTW Series Cond 720) made in Germany; pH values in water, and soil suspensions (1:2.5) were determined by using pH meter (model WTW Series pH 720) made in Germany; cations and anions were determined in water and soil according to

ICARDA (2013). Sodium Adsorption Ratio (SAR) was calculated in water according to Motsara and Roy (2008). Exchangeable Sodium Percentage (ESP) was measured in soil using laboratory tests as described by the Soil Survey Staff (1996). Soluble $N\text{-}NH_4^+$ and $N\text{-}NO_3^-$ in water were measured by using Automatic Micro Kjeldahel Vapodest 30S according to AOAC (1995). Soluble P, Fe, Mn, Cu and B were determined in water acidified with conc. HNO_3 (1 ml Nitric acid for 100 ml water) and filtered through filter paper, "Whitman number 45" (Eaton *et al*., 2005). Available nitrogen in soil was extracted by using KCl (2N) as extractable solution with the ratio of 5gm soil to 50 ml KCl, shaked for 30 min, then filtered and determined using Automatic Micro Kjeldahl method according to AOAC (1995). Available K, P, Fe, Mn, Zn, Cu and B, were extracted according to the method of Soltanpour (1991) by mixture solution of ammonium bicarbonate and diethylene triamine pentaacetic acid 97% (AB-DTPA) with adjusting pH at 7.6; 20 g of soil sample was shaken with 40 ml of the mixture solution to 15 minutes before being filtered through filter paper. Soluble K in water, available K in soil were determined by Flame Photometer, as described by ICARDA (2013). Nutrients (P, Fe, Mn, Zn, Cu and B) in water, soil and plant samples were determined according to Environmental Protection Agency "EPA" (1991) by using inductively coupled plasma (ICP) Spectrometry (model Ultima 2 JY Plasma). Proline contents in olive leaves and fruits were determined by the method of Bates *et al.*, (1973). Proline concentration was determined from standard curve and calculated on mg/100 g fresh weight.

Economic evaluation study:

Economics feasibility/feddan of magnetic iron and Nile fertile for Kalamata olive trees irrigated with saline water either non-magnetic or magnetic water during 2017 & 2018 seasons were calculated according to Heady and Dillon (1961) as follows:

- Total cost of magnetic device/fed. = the price of magnetic device/number of years/number of fed.
- Total cost of adding Nile fertile/feddan = the price of Nile fertile (kg) × amount of adding/tree (2 kg) × number of trees 175/fed.
- Total cost of adding magnetic iron/Feddan = the price of magnetic iron (kg) × amount of adding/tree (500 g) × number of trees 175/fed.
- Fixed cost of agriculture practices = (mineral fertilization, irrigation, pruning, labors, pesticides, harvesting and others) equal for all treatments = 17000 LE/fed. in average of 2017 and 2018 seasons.

The price of Kalamata olive fruits = 16 LE/kg in the average of 2017 and 2018 seasons, according to farm gate price.

- Total gross income (LE/fed.) = Total yield (kg)/fed. × Total price of Kg.
- Net profit (LE/fed.) = Total gross income/Fed. - Total cost/fed.

Statistical analysis: The statistical analysis was conducted according Sendecor and Cochran (1990) by using M stat- c program (1989). New Least significant difference (New LSD) will used to compare between means of treatments according to Waller and Duncan (1969) at probability of 5%. Significant differences among the means of various treatments were compared by new LSD at 5% probability.

Results and Discussion

1- Vegetative growth

Table (5) showed the response of Kalamata olive trees vegetative growth (shoot length, leaf density “number of leaves/meter of shoot” and average of leaf surface area irrigated with saline water either NMW or MW and some of soil amendments (MI, NF and mixture of MI+ NF) added during 2017 and 2018 growing seasons.

The specific effect of irrigation with NMW or MW on vegetative growth of Kalamata olive trees, it is obvious that irrigation with MW gave the highest significant values of shoot length, leaf surface area and leaf density during 2017 and 2018 growing seasons. Concerning the specific effect of soil amendments on leaf surface area it was clear that the mixture of MI+NF treatment gave the highest values in both seasons. On the other hand, the effect of soil amendments on shoot length and leaf density was sporadic. The mixture of MI+NF and the control showed the highest significant value of shoot length in the 1st and 2nd seasons. Regarding leaf density, the control and MI treatments revealed the highest significant values in the first season; meantime the NF gave analogous effect during the second one.

Interaction effect: With referring to the interaction effect between type of irrigation water (NMW or MW) and soil amendments on shoot length, both MI+NF treatment and the control irrigated with MW performed the superior values in both seasons. As for leaf density, the MI+NF irrigated with MW showed the surpassed values during 2017 and 2018 growing seasons. Mixture of MI+NF treatment irrigated with MW gave the highest significant increase in the leaf surface area in both seasons in comparison with other treatments, whereas, the Kalamata trees irrigated either with NMW or MW and treated with NF showed the significant highest values of leaf surface area compared to other treatments in the second season. These results are in agreement with those obtained by Aly *et al.*, (2015) on citrus who reported that magnetic irrigation water enhanced all studied growth characters. Also, Mansour, (2007) and Ismail, *et al.,* (2010) performed that, MI is one of the most important factors affecting plant growth. Application of magnetic iron increased vegetative growth and yield of pepper plant grown under saline irrigation conditions (Taha *et al.*, 2011), and it was suggested that using compost and magnetic iron (300 kg fed^{-1}) improved vegetative growth and yield production of cucumber plants (Shehata *et al.*, 2012). Atawia *et al.,* 2017, found that K-silicate + NF + MI as such treatments enhanced vegetative growth of Valencia orange trees.

2- No. of fruits/shoot

Data tabulated in Table (5) showed that, the effect of irrigation with saline water either NMW or MW and some of soil amendments (MI, NF and mixture of MI+NF) on "number of fruits/shoot of Kalamata olive trees.

The specific effect of irrigation with NMW or MW on number of fruits/shoot of Kalamata olive trees, it is clear that the mixture of MI+NF gave the highest significant values of number of fruits/shoot during 2017 and 2018 growing seasons. Regarding the effect of irrigation with saline water either NMW or MW, data showed that the irrigation with MW surpassed in the first season, While as there weren't any significant differences in values during the second one.

Interaction effect: It is obvious that treatment of mixture of NF+MI surpassed the other treatments and gave the highest significant values in number of fruits/m of shoot in both seasons compared to the other treatments, when olive trees were irrigated with either MW or NMW in both seasons. These results were in harmony with that obtained with Abo-Gabien *et al.*, 2020, found that the effect of magnetic iron (MI) recorded the highest values of productivity of Aggizi olive trees. Salama, *et al.,* (2017) confirmed that, NF recommended to improve growth, yield and quality of orange tree.

3- Total yield/tree:

Specific effect: With respect to the specific effect of the two investigated factors (type of water and soil amendments) on total yield/tree of Kalamata olive trees, data presented in Table (6) indicated that magnetic water significantly increased the total yield/tree. Concerning the specific effect of soil amendments, it was clear that the mixing of MI+NF significantly increased the total yield of Kalamata olive trees compared to other treatments during 2017, 2018 and 2019 seasons.

Table (5): Effect of magnetic iron and Nile fertile on shoot length, leaf density, leaf surface area and number of fruits/shoot of Kalamata olive trees irrigated with non-magnetic or magnetic saline water during 2017 & 2018 seasons:

Treat.	Shoot length (cm)			Leaf density/m			Leaf surface area (cm^2)			No. fruits/shoot		
	NMW*	MW**	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
						2017						
Untreated	10.87^{c}	10.87^{c}	**10.87^{C}**	256.4^{b}	234.2^{c}	**245.3^{A}**	10.51^{d}	12.31^{c}	**11.41^{D}**	2.80^{e}	4.13^{d}	**3.47^{C}**
MI* **	12.67^{b}	9.17^{d}	**10.92^{C}**	211.8^{f}	283.3^{a}	**247.5^{A}**	12.59^{c}	12.36^{c}	**12.48^{C}**	4.67^{b-d}	4.33^{cd}	**4.50^{B}**
NF******	11.40^{c}	12.50^{b}	**11.95^{B}**	210.3^{f}	227.2^{d}	**218.8^{B}**	12.71^{c}	13.60^{b}	**13.16^{B}**	4.93^{a-c}	5.27^{ab}	**5.10^{A}**
MI+NF	12.10^{b}	16.10^{a}	**14.10^{A}**	211.2^{f}	221.3^{e}	**216.3^{B}**	13.08^{bc}	14.38^{a}	**13.73^{A}**	4.93^{a-c}	5.47^{a}	**5.20^{A}**
Mean	**11.76^{B}**	**12.16^{A}**		**222.4B**	**241.5^{A}**		**12.22B**	**13.16^{A}**		**4.33^{B}**	**4.80^{A}**	
						2018						
Untreated	19.30^{d}	24.65^{a}	**21.97^{A}**	94.68^{f}	108.5^{d}	**101.6^{D}**	8.34^{e}	8.49^{c-e}	**8.41^{B}**	3.43^{d}	3.00e	**3.22^{D}**
MI	18.20^{e}	20.20^{c}	**19.20^{C}**	104.5^{e}	113.2^{bc}	**108.9^{C}**	8.42^{de}	8.45^{c-e}	**8.44^{B}**	3.53^{d}	4.33b	**3.93^{C}**
NF	16.44^{f}	19.96^{cd}	**18.20^{D}**	110.4^{cd}	122.6^{a}	**116.5^{A}**	8.61^{b-d}	8.75^{ab}	**8.68^{A}**	4.83^{a}	3.93c	**4.38^{B}**
MI+NF	20.33^{c}	21.22^{b}	**20.78^{B}**	108.3^{d}	116.0^{b}	**112.1^{B}**	8.63^{bc}	8.82^{a}	**8.73^{A}**	4.67^{ab}	5.00a	**4.83^{A}**
Mean	**18.57^{B}**	**21.51^{A}**		**104.5^{B}**	**115.1^{A}**		**8.50^{B}**	**8.63^{A}**		**4.12^{A}**	**4.07^{A}**	

Means of specific and interaction effects followed by the same capital or small letter/s, respectively did not significantly different according to New LSD at 5 %. *NMW: Non-magnetic Water, **MW: Magnetic Water***MI: Magnetic Iron, ****NF: Nile Fertile.

Interaction effect: Regarding the interaction of magnetic water and soil amendments on total yield/tree, it is clear that the addition of mixing of MI+NF irrigated with MW reflect the highest value of yield of Kalamata olive trees in 2017, 2018 and 2019 seasons.

Yadollahpour *et al.*, (2014) found that, MW has demonstrated the ability to reduce water consumption and improve crop yield and plant growth. And Mohamed *et al.*, (2013) showed that, *Citrus sinensis* when treated with magnetic iron achieved the highest significant value in yield. Abo-Gabien, *et al.*, (2020) performed that NF improved flowering and productivity of Aggezi olive cv.

Table (6): Effect of magnetic iron and Nile fertile on total yield/tree of Kalamata olive trees irrigated with non-magnetic or magnetic saline water during the three growing seasons 2017, 2018 and 2019.

Treatments	Total yield/tree (kg)								
	2017			2018			2019		
	NMW*	MW**	Mean	NMW	MW	Mean	NMW	MW	Mean
Untreated	17.00^{g}	20.00^{f}	**18.50^{D}**	11.00^{g}	11.00^{g}	**11.00^{D}**	18.00^{h}	20.00^{g}	**19.00^{D}**
MI* **	20.00^{f}	23.50^{d}	**21.75^{C}**	14.00^{e}	12.50^{f}	**13.25^{C}**	22.00^{f}	24.00^{e}	**23.00^{C}**
NF******	22.00^{e}	26.00^{b}	**24.00^{B}**	17.00^{c}	16.00^{d}	**16.50^{B}**	25.00^{d}	26.00^{c}	**25.50^{B}**
MI+NF	25.00^{c}	28.00^{a}	**26.50^{A}**	17.50^{b}	19.00^{a}	**18.25^{A}**	27.00^{b}	30.00^{a}	**28.50^{A}**
Mean	**21.00^{B}**	**24.38^{A}**		**14.88^{A}**	**14.63^{B}**		**23.00^{B}**	**25.00^{A}**	

Means of specific and interaction effects followed by the same capital or small letter/s, respectively did not significantly different according to New LSD at 5 %. *NMW: Non-magnetic Water, **MW: Magnetic Water***MI: Magnetic Iron, ****NF: Nile Fertile.

4- Fruit characteristics:

Table (7) showed the effect of magnetic iron and Nile fertile on fruit characteristics of Kalamata olive cv. irrigated with NMW and MW:

Specific effect: Although there is non significant difference between NMW and MW on the effect on fruit weight, length, and width of "Kalamata" olive tree in the first season, MW increased significantly the fruit weight and length during the 2nd one, meanwhile, the flesh/fruit weight ratio was affected significantly by MW in both seasons. Regarding to the effect of amendments, all treatments surpassed the control, Whileas the NF and MI+NF gave the highest significant values of fruit width compared to other treatments, meantime the NF achieved the highest values of flesh/fruit (%) during 1st season. During the second season, data revealed that the control, FM and both NF+MI gave the highest values, whereas, fruit length and flesh/fruit weight (%) significantly influenced with the mix of MI+NF only. Nile fertile solely increased the flesh/fruit (%).

As for the interaction effect of different combinations between two studied factors, data obtained during two seasons revealed obviously that all treatments gave the highest significant values compared with the control on the fruit weight, length and width irrigated with both NMW and MW except the effect of FM under NMW for fruit length and width during 2017 growing season, each investigated factor reflected clearly its own specific effect on their various combinations. In regard to the second season, the highest values of fruit length and width were observed with the treatment of Nile fertile and magnetic iron either irrigated with magnetic or nonmagnetic water, meanwhile, the same treatment of fruit weight and flesh/fruit weight % were significantly influenced by MW. These results are in line with those obtained by Murovhi (2013), Aly *et al.,* (2015) and Abobatta, (2015) on Valencia oranges trees; they reported that crop yield and fruit characteristics were improved by NF, MW and MI, respectively. Ashour *et al.,* (2009) on Balady orange trees they found that application of NF increased fruit yield as fruit weight and number of citrus fruits/tree.

5- Leaves macro and micro nutrients content:

Effects of magnetic iron and Nile fertile on macro and micro nutrients content of Kalamata olive leaves irrigated with non-magnetic or magnetic saline water during 2017 and 2018 seasons are illustrated in Table (8):

Specific effect: Results revealed that, Kalamata olive trees irrigated with magnetic water significantly increased macro nutrients (P and K %) in both seasons except N. Regarding the micro nutrients, treatment of magnetic water caused an increase in Mn, Zn, Cu and B in two seasons, at the same time there weren't any response for Fe to the MW, while, NMW surpassed. Regarding the specific effect of soil amendments, treatment of Nile fertile alone can enhance N, P and K % of Kalamata olive leaves in both seasons. Moreover, magnetic iron and NF improved significantly micro nutrients concentration Fe, Mn, Zn, Cu and B in Kalamata olive leaves.

Interaction effect: It is obvious that NF surpassed the other treatments when olive trees were irrigated with either MW or NMW in both seasons. The same analogous effect on P was in the 2nd season and on K was in the 1st one. Furthermore the plants treated with MI combined with NF and irrigated with MW increased the content of micro nutrients Fe, Mn, Zn, Cu and B in Kalamata olive leaves, during the two growing seasons.

The magnetic water treatment showed higher values for mobile forms of N, and enhanced the dissolving of fertilizers in the soil and increased the rate of water absorption, and explained the variation induced by magnetic fields in the ionic currents across the cellular membrane which leads to change in the osmotic pressure. These findings were consistent with that obtained by Maheshwari and Harsharn (2009), Abou El-Yazied *et al.* (2012), Abd El-All *et al.* (2013). Magnetic irrigation water enhanced leaves content of nutrients compared to non-magnetic irrigation water in Valencia Orange (Aly *et al.*, 2015).

Table (7): Effect of magnetic iron and Nile fertile on fruit characteristics of Kalamata olive fruits irrigated with non-magnetic or magnetic saline water during 2017 and 2018 seasons:

Treatments	Fruit weight (gm)			Fruit length (cm)			Fruit width (cm)			Flesh/fruit weight (%)		
	NMW*	MW**	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
2017												
Untreated	4.52^{b}	4.73^{b}	**4.62^{B}**	2.69^{d}	2.79^{c}	**2.74^{B}**	1.72^{c}	1.75^{c}	**1.73^{C}**	85.34^{d}	85.63^{cd}	**85.48^{C}**
MI* **	5.01^{a}	5.07^{a}	**5.04^{A}**	2.80^{bc}	2.86^{a}	**2.83^{A}**	1.78^{b}	1.81^{ab}	**1.80^{B}**	86.23^{b}	86.18^{b}	**86.21^{B}**
NF******	5.13^{a}	5.15^{a}	**5.14^{A}**	2.83^{a-c}	2.86^{a}	**2.85^{A}**	1.83^{a}	1.82^{ab}	**1.82^{A}**	87.17^{a}	86.96^{a}	**87.07^{A}**
MI+NF	5.13^{a}	4.98^{a}	**5.06^{A}**	2.85^{ab}	2.81^{a-c}	**2.83^{A}**	1.83^{a}	1.82^{ab}	**1.83^{A}**	85.89^{bc}	86.88^{a}	**86.39^{B}**
Mean	**4.95^{A}**	**4.98^{A}**		**2.79^{A}**	**2.83^{A}**		**1.79^{A}**	**1.80^{A}**		**86.16^{B}**	**86.41^{A}**	
2018												
Untreated	4.49^{e}	6.17^{a}	**5.33^{A}**	2.70^{e}	2.99^{cd}	**2.85^{BC}**	1.71^{d}	2.01^{a}	**1.86^{AB}**	79.05^{d}	87.32^{a}	**83.19^{B}**
MI	5.51^{bc}	5.15^{cd}	**5.33^{A}**	2.79^{de}	2.84^{cd}	**2.82^{C}**	1.96^{ab}	1.81^{cd}	**1.88^{AB}**	83.99^{b}	83.45^{b}	**83.72^{AB}**
NF	4.86^{de}	4.92^{de}	**4.89^{B}**	2.95^{a-c}	2.87^{b-d}	**2.91^{B}**	1.82^{b-d}	1.84^{b-d}	**1.83^{B}**	81.61^{c}	83.71^{b}	**82.66^{B}**
MI+NF	5.23^{cd}	5.94^{ab}	**5.59^{A}**	2.96^{ab}	3.04^{a}	**3.00^{A}**	1.87^{a-c}	2.00^{a}	**1.94^{A}**	83.95^{b}	85.80^{a}	**84.88^{A}**
Mean	**5.02^{B}**	**5.55^{A}**		**2.85^{B}**	**2.94^{A}**		**1.84A**	**1.92^{A}**		**82.15^{B}**	**85.07^{A}**	

Means of specific and interaction effects followed by the same capital or small letter/s, respectively did not significantly different according to New LSD at 5 %. *NMW: Non-magnetic Water, **MW: Magnetic Water***MI: Magnetic Iron, ****NF: Nile Fertile.

6- Olive fruits macro and micro nutrients content:

Specific effect: The obtained data in Table (9) cleared that, Nile fertile treatment significantly increased nitrogen, phosphorus and potassium (%) in the fruits in both seasons, as compared to the control treatment. Regarding the micro nutrient in Kalamata olive fruits, treatment of MI combined with NF were significantly improved Kalamata olive fruits Fe, Mn, Zn, Cu and Boron contents compared to control treatment. As regard to the effect of type of water is evident that, the plants irrigated with magnetic water significantly increased macro and micro nutrients content of Kalamata olive fruits compared to the trees irrigated with NMW except N and K content which didn't' affected by either NMW or MW.

Regarding the effect of interaction among magnetic water and soil amendments, the results cleared that the highest mean values of macro nutrients (N, P and K) surpassed other treatments in both seasons except N in 1st season didn't take definite trend. As for the micronutrients in Kalamata fruits, all the concentrations was significantly increased by magnetic water and mixture of MI and NF in both seasons, except Cu and Mn which didn't given any significant differences between treatments during the second one.

These results are in harmony with those obtained by, Mohammed *et al.,* (2010) who demonstrated that there are numerous advantages to plant growth resulted from using of natural organic and inorganic products like magnetic iron which improved soil structure, improving water holding capacity and cation exchangeable capacity, and improving crop nutrition from macro and micro nutrients and finally the soil become more energy and vigor. It is worth to mention that the magnetic irrigation gave great impacts on the availability of NPK and micro-nutrients (Fe, Mn, Zn and Cu) all during fertilization season of Apricot, Peach, Flame and Thompson seedless Grape (Fanous *et al.,* 2017).

7- **Proline content in leaves and fruits:**

Table (10) shows the effects of MI and NF on Proline contents in leaves and fruits of Kalamata olive trees irrigated with or without MW during the two growing seasons (2017 and 2018).

Specific effect: Obtained data indicated that proline content in Kalamata leaves and fruits was affected by mixture of NF and MI in leaves in both seasons. Also proline content in fruits showed the same effect in both seasons. Furthermore, the plants treated with NMW had the highest proline content, in both 2017 and 2018 seasons.

Table (8): Effects of magnetic iron and Nile fertile on macro and micronutrients content in Kalamata olive leaves irrigated with non-magnetic or magnetic saline water during 2017 and 2018 seasons:

Treat.	N (%)			P (%)			K (%)			Fe (mg kg^{-1})			Mn (mg kg^{-1})			Zn (mg kg^{-1})			Cu (mg kg^{-1})			B (mg kg^{-1})		
	NMW*	MW**	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
2017																								
Untreated	1.37^{d}	1.38^{d}	**1.37^{D}**	0.09^{e}	0.10^{de}	**0.10^{C}**	0.83^{e}	0.92^{d}	**0.87^{D}**	715.1^{h}	727.3^{g}	**721.2^{D}**	44.63^{e}	45.27^{e}	**44.95^{C}**	18.37^{e}	20.95^{d}	**19.66^{D}**	37.27^{g}	38.97^{fg}	**38.12^{d}**	20.65^{g}	23.00^{f}	**21.82^{D}**
MI***	1.52^{c}	1.55^{c}	**1.54^{C}**	0.11^{c-e}	0.12^{cd}	**0.11^{B}**	0.94^{d}	1.00^{c}	**0.96^{C}**	1112.4^{d}	1207.0^{c}	**1559.7^{B}**	80.97^{d}	85.36^{c}	**83.17^{B}**	26.70^{bc}	28.10^{b}	**27.40^{B}**	50.50^{d}	53.83^{c}	**52.17^{b}**	43.30^{d}	46.20^{c}	**44.75^{B}**
NF****	1.95^{a}	1.98^{a}	**1.97^{A}**	0.14^{b}	0.16^{a}	**0.15^{A}**	1.36^{a}	1.41^{a}	**1.38^{A}**	935.3^{f}	1072.8^{e}	**1004.1^{C}**	79.67^{d}	85.20^{c}	**82.43^{B}**	22.60^{d}	25.64^{c}	**24.12^{C}**	40.02^{f}	42.70^{e}	**41.36^{c}**	38.17^{e}	41.73^{d}	**39.95^{C}**
MI+NF	1.69^{b}	1.72^{b}	**1.71^{B}**	0.13^{bc}	0.15^{a}	**0.14^{A}**	1.11^{b}	1.14^{b}	**1.12^{B}**	2064.8^{a}	1796.6^{b}	**1930.7^{A}**	88.00^{b}	92.27^{a}	**90.13^{A}**	34.10^{a}	36.30^{a}	**35.20^{A}**	83.10^{b}	86.33^{a}	**84.72^{a}**	71.22^{b}	73.48^{a}	**72.35^{A}**
Mean	**1.63^{A}**	**1.66^{A}**		**0.12^{B}**	**0.14^{A}**		**1.05^{B}**	**1.12^{A}**		**1206.9^{A}**	**1200.9^{B}**		**73.32^{B}**	**77.02^{A}**		**25.44^{B}**	**27.75^{A}**		**52.72^{b}**	**55.46^{a}**		**43.33^{B}**	**46.10^{A}**	
2018																								
Untreated	1.44^{d}	1.63c	**1.53^{B}**	0.07^{d}	0.08^{cd}	**0.08^{C}**	1.05^{d}	1.06^{d}	**1.05^{C}**	454.4^{h}	466.7^{g}	**460.6^{D}**	55.93^{f}	57.93^{e}	**56.93^{D}**	16.41^{f}	17.00^{f}	**16.71^{D}**	33.57^{g}	35.07^{f}	**34.32^{d}**	43.87^{c}	35.67^{d}	**39.77^{D}**
MI	1.61^{cd}	1.94a	**1.77^{A}**	0.08^{cd}	0.09^{cd}	**0.08^{BC}**	1.14^{d}	1.19^{d}	**1.16^{C}**	934.2^{c}	881.0^{d}	**907.6^{B}**	64.67^{d}	69.23^{c}	**66.95^{B}**	23.00^{c}	23.81^{c}	**23.41^{B}**	38.63^{d}	42.93^{c}	**40.78^{b}**	52.73^{b}	54.68^{b}	**53.71^{B}**
NF	1.76^{a-c}	1.85ab	**1.81^{A}**	0.11^{ab}	0.12^{a}	**0.11^{A}**	1.64^{b}	2.03^{a}	**1.83^{A}**	866.6^{e}	678.2^{f}	**772.4^{C}**	59.77^{e}	64.33^{d}	**62.05^{C}**	18.90^{e}	21.72^{d}	**20.31^{C}**	36.77^{e}	36.98^{e}	**36.88^{c}**	43.87^{c}	44.20^{c}	**44.03^{C}**
MI+NF	1.68^{bc}	1.92a	**1.80^{A}**	0.09^{cd}	0.09^{bc}	**0.09^{B}**	1.217^{d}	1.41^{c}	**1.31^{B}**	1282.5^{b}	1498.1^{a}	**1390.3^{A}**	75.93^{f}	79.20^{a}	**77.57^{A}**	28.65^{b}	29.57^{a}	**29.11^{A}**	71.80^{b}	75.48^{a}	**73.64^{a}**	52.73^{b}	66.09^{a}	**59.41^{A}**
Mean	**1.62^{B}**	**1.83^{A}**		**0.09^{A}**	**0.09^{A}**		**1.26^{B}**	**1.42^{A}**		**884.4^{A}**	**881.0^{B}**		**64.08^{B}**	**67.68^{A}**		**21.74^{B}**	**23.02^{A}**		**45.19^{b}**	**47.61^{a}**		**48.30^{B}**	**50.16^{A}**	

Means of specific and interaction effects followed by the same capital or small letter/s, respectively did not significantly different according to New LSD at 5 %. *NMW: Non-magnetic Water, **MW: Magnetic Water***MI: Magnetic Iron, ****NF: Nile Fertile.

Table (9): Effects of magnetic iron and Nile fertile on macro and micro nutrients content in Kalamata olive fruits irrigated with non-magnetic or magnetic saline water during 2017 and 2018 seasons:

Treat.	N (%)			P (%)			K (%)			Fe (mg kg^{-1})			Mn (mg kg^{-1})			Zn (mg kg^{-1})			Cu (mg kg^{-1})			B (mg kg^{-1})		
	NMW*	MW**	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
2017																								
Untreated	1.21^{d}	1.22^{cd}	**1.21^{8C}**	0.05^{d}	0.05^{cd}	**0.05^{C}**	0.59^{f}	0.64^{ef}	**0.62^{D}**	321.8^{h}	332.7^{g}	**327.2^{D}**	41.27^{e}	41.72^{de}	**41.49^{D}**	15.14^{g}	15.77^{fg}	**15.45^{C}**	22.47^{g}	23.27^{f}	**22.87^{D}**	42.31^{f}	42.63^{f}	**42.47^{D}**
MI***	1.24^{b-d}	1.25^{b-d}	**1.25^{BC}**	0.06^{b-d}	0.06^{bc}	**0.06^{B}**	0.66^{e}	0.84^{c}	**0.75^{C}**	617.8^{d}	631.2^{c}	**624.5^{B}**	48.24^{c}	49.73^{c}	**49.00^{B}**	28.73^{b}	17.63^{e}	**23.18^{B}**	33.96^{c}	34.71^{c}	**34.33^{B}**	76.85^{c}	77.35^{c}	**77.10^{B}**
NF****	1.49^{a}	1.51^{a}	**1.50^{A}**	0.09^{a}	0.09^{a}	**0.09^{A}**	0.89^{b}	1.01^{a}	**0.95^{A}**	423.7^{g}	443.6^{e}	**433.6^{C}**	42.62^{de}	43.23^{d}	**42.93^{C}**	17.56^{ef}	26.37^{c}	**21.97^{B}**	24.63^{e}	25.43^{d}	**25.03^{C}**	64.37^{e}	65.33^{d}	**64.85^{C}**
MI+NF	1.28^{bc}	1.32^{b}	**1.30^{B}**	0.07^{b}	0.08^{ab}	**0.08^{B}**	0.78^{d}	0.86^{bc}	**0.82^{B}**	733.0^{b}	750.9^{a}	**741.9^{A}**	52.21^{b}	54.12^{a}	**53.17^{A}**	23.37^{d}	30.97^{a}	**27.17^{A}**	44.58^{b}	45.89^{a}	**45.24^{A}**	88.69^{b}	90.99^{a}	**89.84^{A}**
Mean	**1.31^{A}**	**1.33^{A}**		**0.072^{A}**	**0.076^{A}**		**0.734^{B}**	**0.842^{A}**		**524.1^{B}**	**539.6^{A}**		**46.08^{B}**	**47.21^{A}**		**21.20^{B}**	**22.68^{A}**		**31.41^{B}**	**32.32^{A}**		**68.06^{B}**	**69.07^{A}**	
2018																								
Untreated	0.96^{e}	1.15^{d}	**1.05^{D}**	0.12^{d}	0.13cd	**0.13^{D}**	0.68^{C}	0.75^{C}	**0.71C**	464.5^{g}	465.0^{g}	**464.8^{D}**	18.54^{e}	19.35^{e}	**18.94^{D}**	7.42^{f}	7.82^{f}	**7.62^{D}**	24.48^{e}	24.28^{e}	**24.38^{C}**	49.15^{e}	50.60^{e}	**49.87^{E}**
MI	1.18^{cd}	1.30^{bc}	**1.24^{C}**	0.13^{cd}	0.14c	**0.14^{C}**	0.74^{C}	1.00^{B}	**0.87B**	754.4^{d}	845.8^{c}	**800.1^{B}**	30.52^{d}	37.47^{c}	**34.00^{C}**	12.30^{e}	15.49^{d}	**13.90^{C}**	26.73^{d}	26.24^{d}	**16.48^{D}**	64.71^{d}	64.86^{d}	**64.79^{C}**
NF	1.78^{a}	1.79^{a}	**1.79^{A}**	0.17^{b}	0.19a	**0.18^{A}**	1.04^{AB}	1.09^{A}	**1.06A**	525.3^{f}	729.6^{e}	**627.4^{C}**	37.16^{c}	39.88^{b}	**38.52^{B}**	24.37^{c}	25.32^{bc}	**24.84^{B}**	27.24^{b}	26.56^{c}	**26.90^{B}**	74.95^{c}	75.61^{c}	**75.28^{B}**
MI+NF	1.39^{b}	1.77^{a}	**1.58^{B}**	0.14^{c}	0.18b	**0.16^{B}**	0.99^{B}	1.06^{AB}	**1.03A**	872.2^{b}	895.8^{a}	**884.0^{A}**	49.92^{a}	50.80^{a}	**50.36^{A}**	25.61^{b}	28.45^{a}	**27.03^{A}**	32.02^{a}	31.85^{a}	**31.94^{A}**	82.59^{b}	86.45^{a}	**84.52^{A}**
Mean	**1.33^{B}**	**1.506^{A}**		**0.14^{B}**	**0.16^{A}**		**0.866^{A}**	**0.977^{A}**		**654.1^{B}**	**734.1^{A}**		**34.03^{B}**	**36.88^{A}**		**17.43^{B}**	**19.27^{A}**		**22.62^{B}**	**27.23^{A}**		**67.85^{B}**	**69.38^{A}**	

Means of specific and interaction effects followed by the same capital or small letter/s, respectively did not significantly different according to New LSD at 5 %. *NMW: Non-magnetic Water, **MW: Magnetic Water***MI: Magnetic Iron, ****NF: Nile Fertile.

Interaction effect: As for the interaction the plants treated with MI and NF irrigated with NMW had the highest content of proline in their leaves and fruits in both seasons. On the contrary, the tabulated data showed that the lowest leaf and fruit proline content were obtained by MW and control treatments compared with the other ones. The present study revealed that soluble proline in leaves and fruits of Kalamata are highly accumulated with nonmagnetic saline water and increased significantly as response to salt stress. On the contrary, MW reduced the accumulation of proline in both leaves and fruits, it was suggested that proline accumulation may be caused by increased proteolysis or by decreased protein synthesis. Therefore, proline reduced in the leaves and fruit of the trees irrigated with MW and treated with MI +NF, which in turn improved growth and productivity of olive trees. Rejsková *et al.*, (2007) and Ben-Gal, (2011) give strong evidence that proline and other soluble sugars play only minor effect, except Mannitol is the major soluble carbohydrate produced for osmoregulation in olive.

Table (10): Effect of magnetic iron and Nile fertile on proline content in leaves and fruits of Kalamata olive trees irrigated with non-magnetic or magnetic saline water during 2017 and 2018 seasons:

Treatments	Proline (μg g^{-1})					
	Leaves			Fruits		
	NMW*	MW**	Mean	NMW	MW	Mean
			2017			
Untreated	64.03^{cd}	59.14^{e}	**61.58^{D}**	13.58^{d}	11.33^{e}	**12.46^{D}**
MI* **	65.16^{cd}	63.66^{d}	**64.41^{C}**	15.21^{c}	13.08^{d}	**14.15^{C}**
NF** **	70.81^{b}	65.92^{c}	**68.37^{B}**	16.55^{b}	14.89^{c}	**15.72^{B}**
MI+NF	73.07^{a}	70.44^{b}	**71.76^{A}**	17.72^{a}	16.19^{b}	**16.96^{A}**
Mean	**68.27^{A}**	**64.79B**		**15.77^{A}**	**13.87^{B}**	
			2018			
Untreated	65.34^{d}	62.67^{e}	**64.00^{D}**	14.12^{d}	12.74^{c}	**13.43^{D}**
MI	67.51^{c}	66.10^{cd}	**66.80^{C}**	15.74^{c}	13.61^{d}	**14.67^{C}**
NF	72.23^{b}	67.77^{c}	**70.00^{B}**	17.08^{b}	15.49^{c}	**16.29^{B}**
MI+NF	75.43^{a}	72.79^{b}	**74.11^{A}**	18.49^{a}	16.38^{b}	**17.53^{A}**
Mean	**70.13^{A}**	**67.33^{B}**		**16.36^{A}**	**14.61^{B}**	

Means of specific and interaction effects followed by the same capital or small letter/s, respectively did not significantly different according to New LSD at 5 %. *NMW: Non-magnetic Water, **MW: Magnetic Water***MI: Magnetic Iron, ****NF: Nile Fertile.

8- Soil macro and micro nutrients:

Effect of magnetic iron and Nile fertile on macro and micro nutrients content of the soil irrigated with non-magnetic or magnetic saline water during 2017 and 2018 seasons are demonstrated in Table (11):

Specific effect: Results indicated that in both seasons application of MW leads to significant increase in macro-nutrients (N, P and K mg kg^{-1}) and micro-nutrients (Fe, Mn, Zn, Cu, and B

mg kg^{-1}) in experimental soil compared with NMW in 2017 and 2018 seasons. As for the effect of treatment of NF+MI, it is gave the highest significant values of both macro and micro nutrients in both seasons. Concerning the influence of the interaction effect, the highest values of N percentage were recorded in the soil treated with Nile fertile treatment and irrigated with MW at 2017 and 2018 seasons. It is worthily cleared from the obtained results that both magnetic water and mixture of MI+NF improved the content of K and Cu in
both seasons, meantime the same analogues effect was clear on Fe and B. Although the effect of the mixture of NF+MI significantly affected P and Zn values, irrigation with either MW or NMW didn’t show any significant differences. The same effect was on Fe and B during the 2nd season and on manganese in the 1st one.

Abedinpour and Rohani (2017) observed differences in the concentrations of N and P in soil irrigated with magnetically treated water when compared to the control. Maheshwari and Harsharn (2009) mentioned that plants absorb more water of magnetic water MW than non-treated, consequently they uptake more nutrients as a result of water molecules of MW which is reflected on the yield and water productivity. These results indicated that MW have played important role in improving the availability of these nutrients to plants. Selim (2008) indicated that MW induced changes in the mobility of nutrients in the root zone solution which is different from one nutrient to another according to nutrient magnetic susceptibility.

9- Soil chemical characteristics:

Effect of magnetic water, magnetic iron and Nile fertile on electrical conductivity (EC), pH and both cations and anions of the experimental soil are shown in Table (12): It is worth mentioning that, the effect of treatments not becoming statistically significant, does not necessarily mean lack of influence of treatments on the soil salinity, more than slight difference between treatment leading to insignificance. Experimental outcomes demonstrated that, the amount of salt accumulation was represented as the difference between the estimation of EC at the end of the experiment and the initial EC value, (initial EC: 5.35 dS m^{-1}), the average of EC value at the end of first and second season ranged from (4.9 dS m^{-1} to 7.82 dS m^{-1}) in 1st season and from (4.72 dS m^{-1} to 7.69 dS m^{-1}) in 2nd season.

Table (11): Effect of magnetic iron and Nile fertile on macro and micronutrients content in soil of Kalamata olive trees irrigated with non-magnetic or magnetic saline water during 2017 and 2018 seasons:

Treatments	N (mg kg^{-1})			P (mg kg^{-1})			K (mg kg^{-1})			Fe (mg kg^{-1})		
	NMW*	MW**	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
						2017						
Untreated	77.00^{d}	75.27^{e}	**76.14^{C}**	9.08^{e}	10.23^{d}	**9.66^{C}**	132.3^{d}	133.3^{d}	**132.8C**	3.32^{e}	3.66^{e}	**3.49^{D}**
MI***	63.00^{f}	60.28^{g}	**61.64^{D}**	7.38^{f}	8.68^{e}	**8.03^{D}**	104.5^{f}	106.5^{e}	**105.5D**	6.22^{c}	6.81^{b}	**6.51^{B}**
NF****	81.67^{c}	99.94^{a}	**90.80^{B}**	12.05^{c}	13.83^{b}	**12.94^{B}**	135.8^{c}	136.3^{c}	**136.0B**	5.05^{d}	6.28^{bc}	**5.67^{C}**
MI+NF	97.00^{b}	96.88^{b}	**96.94^{A}**	16.35^{a}	17.06^{a}	**16.70^{A}**	146.6^{b}	148.3^{a}	**147.5A**	7.79^{a}	8.06^{a}	**7.92^{A}**
Mean	**79.67^{B}**	**83.09^{A}**		**11.22^{B}**	**12.45^{A}**		**129.8^{B}**	**131.1^{A}**		**5.59^{B}**	**6.20^{A}**	
						2018						
Untreated	69.33^{f}	71.00^{f}	**70.17^{D}**	10.15^{e}	10.41^{e}	**10.28^{D}**	106.6^{f}	108.3^{f}	**107.5^{D}**	3.58^{e}	4.09^{d}	**3.84^{D}**
MI	78.33^{e}	85.00^{d}	**81.67^{C}**	12.37^{a}	13.67^{c}	**13.02^{C}**	135.7^{d}	144.8^{c}	**140.2^{C}**	4.57^{c}	4.79^{c}	**4.68^{C}**
NF	94.11^{c}	107.1^{a}	**100.61^{B}**	13.61^{c}	14.67^{b}	**14.14^{B}**	131.1^{e}	155.2^{b}	**143.2^{B}**	5.08^{b}	5.22^{ab}	**5.15^{B}**
MI+NF	103.3^{b}	103.0^{b}	**103.17^{A}**	18.16^{a}	18.36^{a}	**18.26^{A}**	139.6^{d}	160.1^{a}	**149.9^{A}**	5.41^{a}	5.47^{a}	**5.44^{A}**
Mean	**86.28^{B}**	**91.53^{A}**		**13.57^{B}**	**14.27^{A}**		**128.3^{B}**	**142.1^{A}**		**4.66^{B}**	**4.89^{A}**	

Treatments	Mn (mg kg^{-1})			Zn (mg kg^{-1})			Cu (mg kg^{-1})			B (mg kg^{-1})		
	NMW*	MW**	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
						2017						
Untreated	3.44^{e}	3.86^{de}	**3.65^{D}**	1.15^{e}	1.31^{de}	**1.23^{D}**	2.78^{d}	2.90^{d}	**2.84^{C}**	1.44^{bc}	1.45^{bc}	**1.44^{C}**
MI***	4.47^{d}	5.78^{c}	**5.12^{C}**	1.41^{cd}	1.59^{c}	**1.50^{C}**	1.50^{e}	1.57^{e}	**1.54^{D}**	1.35^{c}	1.85^{a}	**1.60^{B}**
NF****	8.23^{b}	8.52^{b}	**8.37^{B}**	2.42^{b}	2.56^{b}	**2.49^{B}**	3.41^{c}	3.45^{c}	**3.43^{B}**	1.28^{c}	1.49^{bc}	**1.39^{C}**
MI+NF	10.82^{a}	11.16^{a}	**10.99^{A}**	3.63^{a}	3.83^{a}	**3.73^{A}**	7.08^{b}	7.50^{a}	**7.29^{A}**	1.64^{b}	1.88^{a}	**1.76^{A}**
Mean	**6.74^{B}**	**7.33^{A}**		**2.15^{B}**	**2.32^{A}**		**3.69^{B}**	**3.85^{A}**		**1.43^{B}**	**1.67^{A}**	
						2018						
Untreated	2.76^{f}	2.93^{f}	**2.84^{D}**	0.80^{d}	0.88^{d}	**0.84^{D}**	0.84^{e}	0.85^{e}	**0.84^{D}**	1.02^{d}	1.05^{d}	**1.04^{C}**
MI	5.03^{e}	6.34^{d}	**5.69^{C}**	1.60^{c}	1.61^{c}	**1.60^{C}**	2.08^{d}	2.22^{d}	**2.15^{C}**	1.26^{c}	1.29^{bc}	**1.28^{B}**
NF	8.33^{c}	8.56^{c}	**8.44^{B}**	1.70^{b}	1.77^{b}	**1.73^{B}**	3.54^{c}	3.75^{c}	**3.64^{B}**	1.29b^{c}	1.45^{ab}	**1.37^{AB}**
MI+NF	11.71^{b}	12.84^{a}	**12.28^{A}**	2.62^{a}	2.67^{a}	**2.65^{A}**	6.13^{b}	6.52^{a}	**6.33^{A}**	1.41^{a-c}	1.52^{a}	**1.46^{A}**
Mean	**6.96^{B}**	**7.67^{A}**		**1.68^{B}**	**1.73^{A}**		**3.15^{B}**	**3.33^{A}**		**1.25^{A}**	**1.33^{A}**	

Means of specific and interaction effects followed by the same capital or small letter/s, respectively did not significantly different according to New LSD at 5 %. *NMW: Non-magnetic Water, **MW: Magnetic Water***MI: Magnetic Iron, ****NF: Nile Fertile.

Regarding the Specific effect, magnetic water had a significant effect on Cl contents in the soil, MW decrease average Cl content in soil (25.03 and 38.17 meq L^{-1}) in both seasons, respectively. On contrary, magnetic water had no significant effect on Na contents, MW increase Na content in soil (29.10 and 36.82 meq L^{-1}) in both seasons, respectively compared to the soil analysis before the beginning of the experiment. Clearly Na and Cl are the absolute most bothersome particles in soil as they have extremely negative effects on plant development and yield (Mostafazadeh *et al.,* 2011). The amount of soil salinity accumulation decreased compared to the soil irrigated by non-treated saline leaching solution. Also, a decrease in EC and some ions (Na, Cl^-, and SO_4^{-2}) was observed at the end of the experiment (Zlotopolski, 2017). Maheshwari and Harsharn (2009) showed that as to soil properties after plant harvest, the use of magnetically treated irrigation water reduced soil pH but increased soil EC.

10- Economic evaluation study:

Data obtained in Table (13) showed that, the effect of magnetic iron and Nile fertile on net income of Kalamata olive trees irrigated with non-magnetic or magnetic water during 2017 and 2018 seasons. Price Kg^{-1} averaged is 16 LE in 2017 and 2018. Data presented revealed the highest production of Kalamata olive trees (3525 kg fed^{-1}), due to the magnetized saline irrigation water and mixture of Nile fertile and magnetic iron, gave better net return (36362.5 LE) than the other treatments and the control. While magnetic iron and Nile fertile irrigated with non-magnetized water recorded net return (31462.5 LE). On the other hand, the lowest net return (16600 LE) was obtained with autogenic control irrigated with nonmagnetic irrigation water.

Table (12): Effect of magnetic iron and Nile fertile on chemical characteristics of experimental soil of Kalamata olive trees irrigated with non-magnetic or magnetic saline water at the end of 2017 and 2018 seasons:

Treatments	pH (1:2.5)			EC (dS m^{-1})		
	NMW*	MW**	Mean	NMW	MW	Mean
2017						
Untreated	7.30^{cd}	7.50^{ab}	**7.40^{AB}**	5.00^{c}	4.90^{c}	**4.95^{D}**
MI* **	7.22^{d}	7.38^{b-d}	**7.30^{B}**	6.10^{b}	5.24^{c}	**5.67^{C}**
NF****	7.60^{a}	7.38^{b-d}	**7.49^{A}**	6.30^{b}	6.17^{b}	**6.24^{B}**
MI+NF	7.40^{bc}	7.50^{ab}	**7.45^{A}**	7.97^{a}	7.82^{a}	**7.90^{A}**
Mean	**7.38^{A}**	**7.44^{A}**		**6.34^{A}**	**6.03^{B}**	
2018						
Control	7.30^{b}	7.50^{a}	**7.40^{B}**	5.02^{d}	4.72^{d}	**4.87^{C}**
MI	7.50^{a}	7.50^{a}	**7.50^{A}**	7.10^{b}	6.54^{c}	**6.82^{B}**
NF	6.70^{c}	7.50^{a}	**7.10^{C}**	7.04^{b}	6.82^{bc}	**6.93^{B}**
MI+NF	7.32^{b}	7.40^{ab}	**7.36^{B}**	7.84^{a}	7.69^{a}	**7.77^{A}**
Mean	**7.38^{A}**	**7.44^{A}**		**6.34^{A}**	**6.03^{B}**	

	Cations (meq L^{-1})											
	Ca			Mg			Na			K		
Treatments	NMW*	MW**	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
2017												
Untreated	13.51^{g}	17.42^{f}	**15.47^{D}**	10.77^{e}	8.76^{f}	**9.77^{D}**	26.80^{e}	21.32^{g}	**24.06^{C}**	1.62^{d}	1.10^{g}	**1.36^{C}**
MI* **	29.18^{c}	16.08^{f}	**22.63^{C}**	12.91^{c}	10.99^{e}	**11.95^{B}**	20.88^{h}	23.24^{f}	**22.06^{D}**	1.85^{c}	1.37^{f}	**1.61^{B}**
NF****	28.92^{c}	24.64^{d}	**26.78^{B}**	11.45^{d}	10.85^{e}	**11.15^{C}**	27.14^{d}	28.80^{c}	**27.94^{B}**	0.71^{h}	2.02^{b}	**1.37^{C}**
MI+NF	36.76^{a}	31.92^{b}	**34.34^{A}**	22.24^{a}	15.99^{b}	**19.12^{A}**	32.61^{b}	43.03^{a}	**37.82^{A}**	2.36^{a}	1.50^{e}	**1.93^{A}**
Mean	**27.09^{A}**	**22.52^{B}**		**14.34^{A}**	**11.65^{B}**		**26.86^{B}**	**29.10^{A}**		**1.64^{A}**	**1.50^{B}**	
2018												
Untreated	17.75^{g}	16.10^{h}	**16.93^{D}**	9.30^{g}	10.37^{e}	**9.84^{D}**	26.10^{f}	19.32^{h}	**22.71^{D}**	1.06^{e}	0.55^{f}	**0.81^{D}**
MI	33.64^{c}	20.69^{f}	**27.17^{C}**	16.76^{d}	7.69^{h}	**12.23^{C}**	34.61^{c}	48.03^{b}	**41.32^{B}**	1.05^{e}	1.29^{cd}	**1.17^{C}**
NF	30.00^{d}	34.67^{b}	**32.34^{A}**	18.63^{b}	17.86^{c}	**18.25^{A}**	33.35^{d}	25.52^{g}	**29.44^{C}**	1.19^{de}	2.71^{a}	**1.95^{A}**
MI+NF	37.63^{a}	24.99^{e}	**31.31^{B}**	25.77^{a}	9.94^{f}	**17.86^{B}**	28.78^{e}	54.41^{a}	**41.60^{A}**	1.46^{bc}	1.53^{b}	**1.50^{B}**
Mean	**29.76^{A}**	**24.11^{B}**		**17.62^{A}**	**11.47^{B}**		**30.71^{B}**	**36.82^{A}**		**1.19^{B}**	**1.52^{A}**	

	Anions (meq L^{-1})											
	CO_3			HCO_3			Cl			SO_4		
Treatments	NMW*	MW**	Mean	NMW	MW	Mean	NMW	MW	Mean	NMW	MW	Mean
2017												
Untreated	ND*****	ND	ND	4.23^{a}	4.00^{b}	**4.12^{A}**	20.65^{f}	18.45^{g}	**19.55^{D}**	27.81^{g}	26.15^{h}	**26.98^{D}**
MI* **	ND	ND	ND	2.99^{f}	3.46^{d}	**3.23^{D}**	24.80^{d}	15.14^{h}	**19.97^{C}**	37.03^{e}	33.08^{f}	**35.06^{C}**
NF****	ND	ND	ND	3.84^{c}	3.26^{e}	**3.55^{C}**	21.34^{e}	25.95^{c}	**23.65^{B}**	43.04^{c}	37.10^{d}	**40.07^{B}**
MI+NF	ND	ND	ND	3.38^{de}	4.19^{a}	**3.79^{B}**	29.69^{b}	40.57^{a}	**35.13^{A}**	60.90^{a}	47.68^{b}	**54.29^{A}**
Mean	ND	ND		**3.61^{B}**	**3.73^{A}**		**24.12^{B}**	**25.03^{A}**		**42.20^{A}**	**36.00^{B}**	
2018												
Untreated	ND	ND	ND	3.78^{d}	4.25^{b}	**4.02^{B}**	24.54^{g}	23.06^{h}	**24.30^{D}**	25.89^{g}	19.03^{h}	**21.96^{D}**
MI	ND	ND	ND	4.29^{b}	3.99^{c}	**4.14^{A}**	33.13^{c}	47.11^{b}	**40.12^{B}**	48.64^{b}	26.60^{f}	**37.62^{C}**
NF	ND	ND	ND	4.66^{a}	3.13^{e}	**3.90^{C}**	30.48^{f}	32.01^{e}	**31.25^{C}**	48.05^{c}	45.63^{d}	**46.84^{B}**
MI+NF	ND	ND	ND	3.19^{e}	4.26^{b}	**3.73^{D}**	32.31^{d}	50.51^{a}	**41.41^{A}**	58.14^{a}	36.10^{e}	**47.12^{A}**
Mean	ND	ND		**3.98^{A}**	**3.91^{A}**		**30.37^{B}**	**38.17^{A}**		**44.93^{A}**	**31.84^{B}**	

Means of specific and interaction effects followed by the same letter/s, respectively did not significantly different according to New LSD at 5 %. *NMW: Non-magnetic Water, **MW: Magnetic Water***MI: Magnetic Iron, ****NF: Nile Fertile. *****ND= not detected.

Table (13): Economic evaluation of magnetic iron and Nile fertile application on net return of Kalamata olive trees irrigated with non-magnetic or magnetic saline water as average of 2017 and 2018 seasons:

Treat.	Total yield (kg/fed)	Gross income* ($LE.fed^{-1}$)	Fixed Operation cost**	Magnetized water cost***	NF and MI cost****	Total cost*****	Net return ($LE.fed^{-1}$)******
Non- Magnetic water							
Untreated	2100	33600	17000	00	0	17000	16600
MI	2550	40800	17000	00	437	17437	23362.5
NF	2925	46800	17000	00	2100	19100	27700
MI+NF	3187.5	51000	17000	00	2537.5	19537	31462.5
Magnetic water							
Untreated	2325	37200	17000	500	0	17500	19700
MI	2700	43200	17000	500	437.5	17937	25262.5
NF	3150	50400	17000	500	2100	19600	30800
MI+NF	3525	56400	17000	500	2537	20037	36362.5

*Gross income ($LE.fed^{-1}$) = Total yield $kg.fed^{-1}$ (yield/tree x 150 tree/fed) x Price sell of olive fruits (16 LE/Kg)
**Fixed operation cost ($LE.fed^{-1}$) = Cost of irrigation, Labors, mineral and organic fertilization, pesticides, and others.
***Magnetized water cost= price of magnetic device (15000)/number of years (10)/number of feedan (3)
****Price sell of NF = 6 $LE.Kg^{-1}$, Price sell of MI = 2 $LE.Kg^{-1}$.
*****Total cost ($LE.fed^{-1}$) = Fixed operation cost + magnetized water, Nile fertile and magnetic iron cost. ******Net return ($LE.fed^{-1}$) = Gross income - Total cost.

Conclusion:

It could be concluded that; 1) Magnetized saline irrigation water and mixture of magnetic iron and Nile fertile enhanced vegetative growth, number of fruits/shoot, total yield/tree as well as fruit physical properties of Kalamata olive fruits; 2) Magnetic water with Nile fertile improved macro-nutrients (N, P and K) and micro nutrients (Fe, Cu, Mn, Zn and B) content in the leaves and fruits of Kalamata olive trees; 3) Magnetic water with mixture of MI+NF gave the highest recorded value of macro nutrients, except nitrogen, and micro nutrients in soil in all studied seasons; 4) Nitrogen concentration improved by using MW with NF alone; 5) The least value of proline content was obtained with control treatment irrigated by MW and 6) It is suffice to say that, we can recommend for "Kalamata" olive cv. trees planted in the western desert and treated with NF+MI and irrigated with magnetized saline water to improve growth, fruiting and productivity, also, it is the best economic recommended treatment with the highest net return value.

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الملخص العربي

تأثر ماء الرى المالح الممغنط ومحسنات التربة على نمو وإنتاجية أشجار الزيتون صنف الكلاماتا.

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تم إجراء التجربه في مزرعة خاصة (السلام الدولية للتنمية والاستثمار الزراعي) كيلو 64 بطريق مصر الإسكندرية الصحراوي – مصر. لدراسة تأثير ماء الري المالح الممغنط ومصلحات التربة (حديد مغناطيسي ونايل فرتيل) علي النمو الخضري وخصائص الثمار وحالة العناصر في الأوراق والثمار وبعض خصائص التربة بالإضافة إلي محتوي البرولين في الأوراق والثمار تحت ظروف ملوحة تربة 3430 جزء في المليون وملوحة مياه الري 3904 جزء في المليون خلال موسمي الدراسة 2016–2017 / 2017–2018 والإنتاجية فقط خلال ثلاثة مواسم 2016–2017 / 2017– 2018 / 2018–2019. أظهرت النتائج أن الماء الممغنط مع الحديد المغناطيسي والنايل فرتيل أدي الي التحسين المعنوي في النمو الخضري (طول الفرع – الكثافة الورقية – مساحة سطح الورقة) ، عدد الثمار/الفرع ، الإنتاج الكلي /للشجرة ، الخصائص الطبيعية للثمار وأيضا محتوي الاوراق والثمار والتربة من العناصر الكبري والصغري في كلا موسمي الدراسة الاول والثاني. أنخفض محتوي البرولين في كل المعاملات بإستخدام الماء الممغنط مقارنة بماء الري المالح الغير معامل في الأوراق والثمار. كما أوضحت النتائج ان الري بإستخدام الماء الممغنط ومصلحات التربة (الحديد المغناطيسي والنايل فرتيل) حققت أعلي عائد مادي حوالي 36362.5 للفدان مقارنة ببقية المعاملات (متوسط موسمي الدراسة 2017/2016–2018/2017). وعليه يمكن التوصية بإستخدام الماء الممغنط والتسميد بالنايل فرتيل (2 كجم للشجرة/العام) بالإضافة الي الحديد المعناطيسي (500 جم للشجره) تحت ظروف الري بالماء المالح 3904 جزء في المليون وملوحة تربة 3430 جزء في المليون لخفض أضرار الملوحة وتحسين مواصفات النمو الخضري وخصائص المحصول وزيادة صافي الدخل لأشجار الزيتون صنف الكلاماتا.