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Minimizing the Adverse Effects of Irrigation with Saline Water on Olive Trees, Picual and Manzanillo Cultivars

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Abstract: This study was conducted on thirteen years old olive trees (Picual and Manzanillo cultivars) irrigated with ground water (EC 7.06 dSm^{-1}/ 5648 ppm) to minimize the adverse effects of salinity by using two concentrations of Potassium silicate (500 and 1000 ppm), Calcium nitrate (1000 and 2000 ppm), Salicylic acid (50 and 100 ppm) and Naphthalene acetic acid (50 and 100 ppm) as foliar applications in mid-February during 2017 and 2018 seasons. Vegetative, leaf minerals content, flowering, fruiting, yield, fresh fruit and pulp weight as well as oil content were studied. Results revealed that using NAA (50 ppm) enhanced leaf area and perfect flower percentage. NAA (50 and 100 ppm) improved leaf P percentage. Leaf water content percentage was enhanced when Potassium silicate (500 ppm) was applied. Leaf K and final fruit set percentages were improved by application of Potassium silicate (1000 ppm). Spraying Salicylic acid (100) decreased leaf Na percentage and fruit moisture content but increased fruit weight and leaf P percentage. Calcium nitrate (2000 ppm) enhanced both leaf N and Ca percentages and when applied with 1000 ppm increased fresh pulp weight. Picual significantly surpassed Manzanillo in leaf area, water content, leaf K, N, P and Ca percentages. Picual trees achieved decreased leaf Na content and fruit moisture percentages but increased yield and oil content percentage. Manzanillo trees scored higher significant values in both fresh fruit and pulp weight. It's recommended to apply NAA (50 ppm) foliar application in mid-February to enhance yield and oil percentage.

Key words: Picual · Manzanillo · Salinity · Flowering · Yield · Oil content

INTRODUCTION

Water demand is increasing worldwide due to fast population growth rates, living standards improvement, expansion of irrigation schemes and global warming [1]. Affected by water scarcity, Mediterranean Basin region's water supplies are subject to degradation processes, which increases the shortage of water [2]. This degradation leads to limiting the agricultural development and as a consequence, agriculture sector is forced to meet its increasing demands by utilizing low quality water (saline water). Using saline water for irrigation requires an adequate understanding of how salts affecting soil characteristics and plant performance [3].

Olive (*Olea europaea* L.) is a long-lived evergreen tree, native to the Mediterranean basin and one of its major crops. According to FAO statistics [4], olive harvested area in Egypt was 214147.62 Feddans, producing 1080091 Tons during 2019. Olive tree is a moderately tolerant to salinity [3]. High salinity causes decline in olive leaf area, mineral nutrients imbalance, reduces olive tree yield and decreases oil content [5-17].

Many studies concluded that the upcoming growth regulators and minerals were effective in improving yield, fruit quality and ameliorate the adverse effects of salinity:

Salicylic acid [$C_7H_6O_3$] minimizes the effects of stress conditions and enhances natural hormones which regulate plant growth and development, plays an important role in regulating and resisting abiotic stresses and enhances yield and fruit quality of different crops [18-23].

Naphthalene acetic acid (NAA) [$C_{12}H_{10}O_2$] improves physiological processes, growth, maturity and the quality of fruits. NAA encourages cell division and enhances cells enlargement [24]. A positive correlation between NAA application, the vegetative growth and chlorophyll

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content was reported [25]. NAA improved fruit set [22]. NAA increases fruit growth rate which results in a bigger size without any reduction in yield [26].

It was reported that potassium (K), silicon (Si) and calcium (Ca) alleviates K/Na ratio [27, 28, 10]. Also, K, Si and Ca increase salt tolerance [27, 6, 10]. Kour *et al*. [29] found that K plays an important role in photosynthesis, respiratory processes, nitrogen compounds and carbohydrates synthesis, carbohydrate transport and movement of water. Si mediated tolerance to salt stress through reduction in ion toxicity, plant water balance maintenance, increase in mineral uptake, phyto-hormones oxidative stress reduction and gas exchange attributes modification [27].

Considering all the previously mentioned scientific facts and with a view to enhance growth, flowering, fruiting, yield and oil content of Picual and Manzanillo, a field experiment was carried out with an objective to decrease the adverse effects of irrigation with saline water by foliar applications of Potassium silicate [K_2O_3Si], Calcium nitrate [$Ca(NO_3)_2$], Salicylic acid [$C_7H_6O_3$] and Naphthalene acetic acid [$C_{12}H_{10}O_2$].

MATERIALS AND METHODS

Plant Materials and Treatments: The present study was carried out during two successive seasons 2017 and 2018 on thirteen years old Manzanillo and Picual trees, which were propagated by leafy stem cuttings, growing in Al-Salam International for Development and Agricultural Investment private farm about 64 Kilometer from Cairo Alexandria Desert Road; situated at 30° 268` 215`` N latitude, 30° 806` 534`` E longitude. The trees were planted at 6×3 m apart under drip irrigation system (4400 m^3 /fed.) and subjected to the regularly recommended culture practices and free from pathogens and physiological disorders.

Soil and water samples were collected. Soil samples were air-dried, grounded to pass through a 2.0 mm sieve and then thoroughly mixed. Soil texture was sandy loam. Chemical properties of the soil (0-30 cm and 30-60 cm) and water samples were determined in Soils, Water & Environment Res. Ins. Labs and are given in Tables 1, 2 and 3, respectively. Average temperature of both seasons was recorded (Fig. 1).

This experiment was designed to study the effect of spraying Picual and Manzanillo cultivars in mid-February, before beginning of flowering according to Abd El-Razek *et al.* [20] and Abo-El-Ez *et al.* [30] with the following:

- Water (for control trees).
- Potassium silicate [K_2O_3Si] 1000 and 500 ppm.
- Calcium nitrate [$Ca(NO_3)_2$] 2000 and 1000 ppm.
- Salicylic acid [$C_7H_6O_3$] 100 and 50 ppm.
- Naphthalene acetic acid [$C_{12}H_{10}O_2$] 100 and 50 ppm.

The previously mentioned treatments were sprayed using ground water with EC not exceeding 800 ppm. A surfactant was added to all spray solutions and pH was adjusted to 6.5. For each concentration, sixty-one trees were sprayed and on year trees for both seasons were selected. Each treatment was represented by three replicates (a tree for each replicate).

The Following Parameters Were Recorded

Leaf Area (cm^2): Leaf area was reported to be sensitive to salinity [16]. Approximately 40 adult leaves were taken from the middle section of selected nonbearing shoots in July to determine average leaf surface area according to Ahmed and Morsy [31] using the following equation:

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

Leaf Water Content Percentage: Samples of mature full expanded leaves were taken from the middle portion of the selected nonbearing shoots in July. Four leaves for each replicate were collected, fresh weighted (FW), oven dried at 70°C for 72 hours and then dry weighted (DW). Leaf water content was calculated as:

LWC (%) = 100 (FW-DW)/FW

Leaf Minerals Content: Leaf samples were collected in July, then washed thoroughly with distilled water to remove all soil, dust and mineral particles. Leaf dry samples as prepared above were digested in a mixture of sulphuric and perchloric acids according to Piper [32] and used to estimate leaf Na, K, P, N and Ca contents and were measured by atomic absorption (model Perkin Elmer 400) and expressed as percentage [33].

Flowering and Fruit Setting: Twelve shoots per each selected tree were employed to determine the flowering density (average number of inflorescences per one meter) and was calculated according to Mofeed [34].

Sample of approximately sixty inflorescences at balloon stage from each tree were randomly taken from the middle portion of shoots to calculate perfect flowers percentage [35, 36].

Table 1: Chemical characteristics, available macro and micronutrients of the tested soil sample (0-30 cm) collected from the experimental area

			mEq/L.							
Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	Cl^-	So_4^{--}	pH (1:2.5)	EC dSm^{-1} (1:5)	SP
18.42	16.91	29.31	0.64	-	4.72	27.12	33.44	8.00	7.08	20.00
			mg/Kg							
N	P	K	Cu	Fe	Mn	Zn				
189.00	6.88	113.00	0.04	0.51	0.31	0.152				

Table 2: Chemical characteristics, available macro and micronutrients of the tested soil sample (30-60 cm) collected from the experimental area

			mEq/L.							
Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	Cl^-	So_4^{--}	pH (1:2.5)	EC dSm^{-1} (1:5)	SP
7.89	2.97	12.90	0.26	-	2.83	14.41	6.78	7.20	2.68	20.00
			mg/Kg							
N	P	K	Cu	Fe	Mn	Zn				
72.00	6.22	59.00	0.048	0.678	0.248	0.124				

Table 3: Chemical properties and available macro and micronutrients of the tested ground water sample collected from the experimental area

			mEq/L							
Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	Cl^-	So_4^{--}	pH	EC dSm^{-1}	Ppm
16.06	11.74	38.26	0.17	0.00	1.75	29.15	35.33	8.30	7.06	5648.0
			mg/L							
N (NH_4^+)	N (NO_3^-)	P	B	Zn	Fe	Mn	Cu (µg/L)	SAR		
2.80	4.90	0.03	0.02	0.013	0.135	0.096	<0.20	10.26		

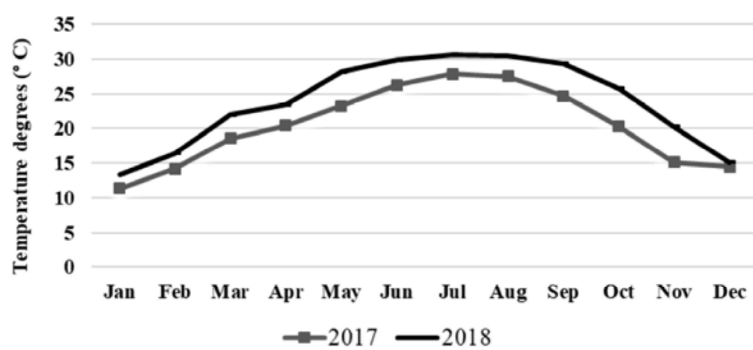

Fig. 1: Average temperature of 2017 and 2018 seasons

Final fruit set percentage: Was determined after 60 days from full bloom following the equation [37]:

Fruit set percentage = No. of fruits × 100/ No. of total flowers.

Fruit retention percentage: was calculated using the equation:

Fruit retention percentage = final fruit set × 100/ initial fruit set.

Fresh Fruit and Pulp Weight (g): Sixty fruits/treatment were randomly collected in September. Average fruit weight (g) was estimated. Also, pulp weight (g) was calculated using the formula:

Pulp weight (g) = average fruit weight – average stone weight.

Yield (Kg): Fruits of each experimented tree was harvested at light green (straw) of each cultivar and weighted.

Fruit Moisture and Oil Content Percentages: Fruit moisture content percentage was determined after drying fruits in oven at 70°C until constant weight.

Oil content was measured by Soxhlet fat extraction apparatus using petroleum ether (60-80°C) as described in the A.O.A.C. [38] and presented as percentage of fruit dry matter.

Statistical Analysis: Data recorded in 2017 and 2018 seasons were subjected to analysis of variance (ANOVA) for factorial design (the treatments and the two cultivars) in a randomized complete blocks according to Snedecor and Cochran [39] and the means were distinguished according to the Duncan multiple range test at the level of probability 5% [40].

RESULTS AND DISSCUSIONS

Leaf Area (cm^2): In both seasons (Table 4), NAA (50 ppm) treatment proved to be the best (5.50 and 5.52 cm^2, respectively), while Calcium nitrate (1000 ppm) treatment took the other way around, also Picual was superior in this regard. NAA (50 ppm) with Picual recorded the highest values in both seasons (5.76 and 5.80 cm^2, respectively). Lower values were obtained by spraying Manzanillo with both concentrations of Calcium nitrate treatments. High salinity causes decline in olive leaf area [3, 41, 8, 15, 5-7]. The above results are in agreement with Al-Qady *et al*. [25] who reported that NAA improved leaf area of Bashyki olive transplants. This may be due to increase growth resulted from NAA foliar spray and its role in cell division and elongation [24]. Leaf area of Picual trees exceeded that of Manzanillo trees in both seasons [42, 43].

Leaf Water Content Percentage: Results revealed that all treatments increased leaf water content than the control treatment and this was true during the two studied seasons (Table 5). Potassium silicate (500 ppm) treatment surpassed all the other treatments in both seasons recording 52.75 and 52.50%, respectively. Picual was significantly superior in this concern in both seasons. Using Potassium silicate (1000 and 500 ppm) with Picual gave higher values in 2017 and 2018 seasons (53.19 and 52.89% as well as 52.39 and 52.79%, respectively), while control treatment with Manzanillo recorded the lowest values. Water uptake by salinized olive plants is reduced [44]. Kour *et al*. [29] reported that K plays an important role in physiological and biochemical functions including movement of water. Fernández-Escobar [45] concluded that K plays an important role in the regulation of water status in olive. Larbi *et al*. [10] found that K application improved water status of Arbequina I18 two-year-old plants irrigated with saline solutions. Water balance maintenance is a key mechanism involved in Si-mediated of salt stress [46]. Meng *et al*. [47] proved that osmotic stress was induced with the rise of NaCl concentration in the soil, which obstructed the root from absorbing water, resulting in leaf water deficit. Si application improved the leaf water balance and alleviate salt-induced osmotic stress. Higher leaf water percentage of Picual gave evidence that Picual trees are more tolerant to salinity than Manzanillo ones. This result is in harmony with Hassan *et al*. [48] who found that Manzanillo one-year-old seedlings were more sensitive to salinity than Picual ones.

Leaf Mineral Content

Leaf Sodium Content Percentage: Control treatments showed the highest percentage in both seasons, recording 0.445 and 0.450 %, respectively (Table 6). Lower percentages were given by Salicylic acid (100 and 50 ppm) and Potassium silicate (1000 ppm) in 2017 season, while in 2018 season, Salicylic acid (100 ppm) recorded the lowest percentage with insignificant differences with all treatments except control and Potassium silicate (500 ppm). Manzanillo significantly achieved higher leaf percentages in both seasons. Control treatments when applied to Manzanillo showed the highest percentage (0.480 %) and this trend was true for both seasons. Spraying Picual with both Salicylic acid (100 ppm) and Potassium silicate (1000 ppm) treatments resulted in higher decrease in Na percentage (0.250 %) in the 1st season, but in the 2nd season, Salicylic acid (100 ppm) and Calcium nitrate (2000 ppm) treatments gave the lowest percentage (0.310 %). Na^+ uptake reduction and accumulation by plants is one of the most important mechanisms of plant resistance to salt stress [46]. Salicylic acid plays an important role in regulating and resisting abiotic stresses [19, 6]. Salicylic acid (1 mmol L^{-1}) was able to restrict Na^+ ions transport from the roots to the leaves of Oueslati olive plants limiting its toxicity in the sensitive organs [49]. Larbi *et al.* [10] added that leaf Na concentration showed that K supplementary might act mainly by inhibiting Na translocation from root to leaves, enhancing the Na exclusion mechanism at root level. Hassan *et al.* [48] found that leaf Na^+ concentration of Picual was lower than that of Manzanillo.

Leaf Potassium Content Percentage: Spraying Potassium silicate (1000 ppm) treatment resulted in higher potassium concentrations, whilst control treatments recorded the lowest values in both seasons Table (7). In 2017 and 2018 seasons, higher potassium content in Picual leaves than Manzanillo ones was significantly observed. During the both seasons, application of Potassium silicate (1000 ppm) to Picual gave the highest values, whilst control application to Manzanillo recorded lowest values.

Table 4: The effect of treatments and olive cultivars on leaf area (cm^2) in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	-------------- 2017 -----------			-------------- 2018 -----------		
Control	4.95d-f	5.32b-d	5.14BC	4.97de	5.37bc	5.17BC
Potassium silicate 1000 ppm	5.00c-f	5.50ab	5.25AB	5.02c-e	5.57bc	5.30AB
Potassium silicate 500 ppm	5.26b-d	4.77e-g	5.02BC	5.21b-d	4.78ef	5.00CD
Calcium nitrate 2000 ppm	4.43g	5.30b-d	4.87CD	4.47f	5.36bc	4.92D
Calcium nitrate 1000 ppm	4.48g	4.74fg	4.61D	4.57f	4.79ef	4.68E
Salicylic acid 100 ppm	5.18b-e	5.29b-d	5.24AB	5.28b-d	5.31b-d	5.30AB
Salicylic acid 50 ppm	5.12b-f	5.33b-d	5.23AB	5.22b-d	5.33b-d	5.28AB
Naphthalene acetic acid 100 ppm	5.14b-f	5.45a-c	5.30AB	5.22b-d	5.57ab	5.40AB
Naphthalene acetic acid 50 ppm	5.23b-d	5.76a	5.50A	5.24b-d	5.80a	5.52A
Mean	4.98B	5.27A		5.02B	5.32A	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Table 5: The effect of treatments and olive cultivars on leaf water percentage in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	-------------- 2017 -----------			-------------- 2018 -----------		
Control	48.83e	51.14b-d	49.99C	48.38e	50.36cd	49.37C
Potassium silicate 1000 ppm	51.99a-d	53.19a	52.59A	51.22a-d	52.39ab	51.81AB
Potassium silicate 500 ppm	52.61a-c	52.89ab	52.75A	52.22ab	52.79a	52.50A
Calcium nitrate 2000 ppm	51.13b-d	51.11b-d	51.12BC	51.11a-d	50.90b-d	51.00B
Calcium nitrate 1000 ppm	50.64cd	52.83ab	51.73AB	50.25cd	52.29ab	51.27B
Salicylic acid 100 ppm	50.48de	51.88a-d	51.18BC	50.05d	51.85a-c	50.95B
Salicylic acid 50 ppm	51.71a-d	51.22a-d	51.46AB	51.58a-d	50.81b-d	51.19B
Naphthalene acetic acid 100 ppm	51.94a-d	51.30a-d	51.62AB	51.75a-d	51.00b-d	51.37B
Naphthalene acetic acid 50 ppm	51.65a-d	52.54a-c	52.09AB	51.05a-d	51.44a-d	51.24B
Mean	51.22B	52.01A		50.84B	51.53A	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Table 6: The effect of treatments and olive cultivars on sodium content percentage in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	-------------- 2017 -----------			-------------- 2018 -----------		Mean
Control	0.480a	0.410b	0.445A	0.480a	0.400b	0.450A
Potassium silicate 1000 ppm	0.310f-h	0.250j	0.280E	0.360c-f	0.330e-g	0.345BC
Potassium silicate 500 ppm	0.410b	0.370cd	0.390BC	0.390bc	0.330e-g	0.360B
Calcium nitrate 2000 ppm	0.380b-d	0.360de	0.370C	0.350c-g	0.310g	0.330BC
Calcium nitrate 1000 ppm	0.400bc	0.390b-d	0.395B	0.360c-f	0.320fg	0.340BC
Salicylic acid 100 ppm	0.280h-j	0.250j	0.265E	0.340d-g	0.310g	0.325C
Salicylic acid 50 ppm	0.280h-j	0.270ij	0.275E	0.380b-d	0.320fg	0.350BC
Naphthalene acetic acid 100 ppm	0.320fg	0.260ij	0.290DE	0.370c-e	0.330e-g	0.350BC
Naphthalene acetic acid 50 ppm	0.330ef	0.290g-i	0.310D	0.380b-d	0.320fg	0.350BC
Mean	0.350A	0.320B		0.380A	0.330B	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Application of KNO_3 (4 %) seems to be beneficial for nutritional status olive orchard [50]. Abd-Elrhman and Attia [6] reported that under salinity conditions, spraying KNO_3 increased Manzanillo leaf K content. The additional supply of K as KNO_3 at 40 mM to two-year-old Arbequina I18 plants grown with 200 mM NaCl increased K level in all plant tissues, while at 10 mM increased K content in young and mature leaves [10].

Leaf Phosphorus Content Percentage: Using NAA (100 and 50 ppm) and Salicylic acid (100 ppm) treatments gave higher phosphorus content, whilst control treatments recorded lowest values in 2017 and 2018 seasons (Table, 8). Picual significantly surpassed Manzanillo in leaf P content percentages in both seasons. Higher leaf P values were obtained by applying NAA (100 and 50 ppm) and Salicylic acid (100 ppm) treatments

Table 7: The effect of treatments and olive cultivars on potassium content percentage in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	-------------- 2017	-----------		-------------- 2018	-----------	
Control	0.65i	0.74h	0.70E	0.61f	0.72e	0.67D
Potassium silicate 1000 ppm	0.88bc	1.02a	0.95A	0.92b	1.00a	0.96A
Potassium silicate 500 ppm	0.86cd	1.01a	0.94A	0.89b	0.91b	0.90B
Calcium nitrate 2000 ppm	0.75h	0.78gh	0.77D	0.74de	0.77c-e	0.76C
Calcium nitrate 1000 ppm	0.81e-g	0.91b	0.86B	0.76de	0.78c-e	0.77C
Salicylic acid 100 ppm	0.84c-f	0.88bc	0.86B	0.81cd	0.80c-e	0.81C
Salicylic acid 50 ppm	0.82d-g	0.85c-e	0.84BC	0.79c-e	0.80c-e	0.80C
Naphthalene acetic acid 100 ppm	0.81e-g	0.84c-f	0.83C	0.73de	0.85bc	0.79C
Naphthalene acetic acid 50 ppm	0.80fg	0.85c-e	0.83C	0.80c-e	0.74de	0.77C
Mean	0.80B	0.88A		0.78B	0.82A	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Table 8: The effect of treatments and olive cultivars on phosphorus content percentage in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	-------------- 2017	-----------		-------------- 2018	-----------	
Control	0.130g	0.180ef	0.155E	0.120c	0.140b	0.130D
Potassium silicate 1000 ppm	0.180ef	0.210c-e	0.195CD	0.150ab	0.170a	0.160AB
Potassium silicate 500 ppm	0.143fg	0.190d-f	0.167DE	0.150ab	0.150ab	0.150BC
Calcium nitrate 2000 ppm	0.190d-f	0.240b-d	0.215BC	0.150ab	0.150ab	0.150BC
Calcium nitrate 1000 ppm	0.180ef	0.220c-e	0.200C	0.140b	0.150ab	0.145C
Salicylic acid 100 ppm	0.220c-e	0.250a-c	0.235AB	0.170a	0.160ab	0.165A
Salicylic acid 50 ppm	0.190d-f	0.240b-d	0.215BC	0.150ab	0.150ab	0.150BC
Naphthalene acetic acid 100 ppm	0.240b-d	0.270ab	0.255A	0.153ab	0.170a	0.162AB
Naphthalene acetic acid 50 ppm	0.240b-d	0.290a	0.265A	0.143b	0.170a	0.157A-C
Mean	0.190B	0.232A		0.147B	0.157A	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

to Picual, however control treatments when sprayed on Manzanillo gave lowest values in both studied seasons. NAA helps to increase the absorption of mineral elements from the soil [51]. NAA role in the division and cell elongation was reported by Al-Khafaji [24] which leads to increase soil elements uptake, thus increase their content in the leaves [52]. Abd-Elrhman and Attia [6] found that different concentrations of Salicylic acid increased Manzanillo leaf P content under salinity stress.

Leaf Nitrogen Content Percentage: Applying Calcium nitrate (2000 ppm) treatment recorded the highest leaf nitrogen content (Table 9), however control treatment gave the lowest percentages in both seasons. Picual significantly exceeded Manzanillo and this trend was true in the two studied seasons. Spraying Picual with Calcium nitrate (2000 ppm) treatment recorded higher leaf nitrogen content than the others, while control treatment with Manzanillo showed the lowest percentages in both seasons. Ben Abdallah *et al*. [53] found that under salinity stress conditions, leaf nitrogen was decreased. Similarly, Hegazi *et al*. [50] noted that spraying Picual with KNO_3 (4 %) recorded the highest leaf N content in both seasons. Abd-Elrhman and Attia [6] mentioned that spraying Manzanillo trees with KNO_3 (10, 20 and 30 g/L) significantly increased leaf N content.

Leaf Calcium Content Percentage: The effect of treatments and olive cultivars on calcium percentage in 2017 and 2018 seasons is shown in Table (10). Calcium nitrate (2000 ppm) treatment proved to be the best in both seasons (1.12 and 1.06 %, respectively) with insignificant difference with Calcium nitrate (1000 ppm) just in 2018 season. Control treatment significantly showed the lowest Ca content in both seasons. Picual significantly surpassed Manzanillo in both seasons. During the two studied seasons, best percentages were recorded by Calcium nitrate (2000 ppm) when applied to Picual, while using control treatment with Manzanillo resulted in the lowest percentages. Similarly, Larbi *et al.* [10] reported that the addition of 10 or 40 mM $CaCl_2$ to the 100 or 200 mM NaCl nutrient solution increased Ca concentration in all the analyzed Arbequina I18 plant tissues. Also, higher calcium content was recorded in the leaf of calcium-treated trees for Manzanillo and Ascolano [54].

Table 9: The effect of treatments and olive cultivars on nitrogen content percentage in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	-------------- 2017	------------		-------------- 2018	-----------	
Control	1.05k	1.22j	1.14F	1.28i	1.37h	1.33G
Potassium silicate 1000 ppm	1.91f	2.00e	1.96C	1.96cd	2.09b	2.03C
Potassium silicate 500 ppm	1.64hi	2.00e	1.82D	1.91de	1.96cd	1.94D
Calcium nitrate 2000 ppm	2.21c	2.50a	2.36A	2.10b	2.37a	2.24A
Calcium nitrate 1000 ppm	2.09d	2.41b	2.25B	2.00c	2.32a	2.16B
Salicylic acid 100 ppm	1.99e	1.90f	1.95C	1.96cd	2.12b	2.04C
Salicylic acid 50 ppm	1.81g	1.85fg	1.83D	1.82f	2.09b	1.96D
Naphthalene acetic acid 100 ppm	1.56i	1.68h	1.62E	1.82f	1.93c-e	1.87E
Naphthalene acetic acid 50 ppm	1.60i	1.60i	1.60E	1.73h	1.87ef	1.80F
Mean	1.76B	1.91A		1.84B	2.01A	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Table 10: The effect of treatments and olive cultivars on calcium content percentage in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	-------------- 2017	------------		-------------- 2018	-----------	
Control	0.65h	0.74g	0.70G	0.57h	0.66fg	0.62E
Potassium silicate 1000 ppm	0.95cd	1.01bc	0.98C	0.68e-g	0.74c-f	0.71CD
Potassium silicate 500 ppm	0.81fg	0.83ef	0.82F	0.64gh	0.72d-g	0.68D
Calcium nitrate 2000 ppm	1.03bc	1.20a	1.12A	1.00b	1.11a	1.06A
Calcium nitrate 1000 ppm	1.02bc	1.08b	1.05B	1.02b	1.07ab	1.05A
Salicylic acid 100 ppm	0.90de	1.00bc	0.95CD	0.75c-e	0.75c-e	0.75BC
Salicylic acid 50 ppm	0.88d-f	0.95cd	0.91DE	0.79cd	0.70e-g	0.75BC
Naphthalene acetic acid 100 ppm	0.83ef	0.90de	0.87EF	0.72d-g	0.72d-g	0.72CD
Naphthalene acetic acid 50 ppm	0.80fg	0.88d-f	0.84F	0.76c-e	0.81c	0.79B
Mean	0.87B	0.95A		0.77B	0.81A	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Table 11: The effect of treatments and olive cultivars on flowering density (inflorescence No./m) in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	-------------- 2017	------------		-------------- 2018	-----------	
Control	44.74j	57.08f	50.91D	33.34ef	59.56b	46.45CD
Potassium silicate 1000 ppm	46.94ij	51.05g-i	49.00D	35.29ef	38.33e	36.81E
Potassium silicate 500 ppm	46.62ij	67.68cd	57.15C	45.00d	51.56c	48.28B-D
Calcium nitrate 2000 ppm	54.25f-h	71.88bc	63.07B	33.58ef	44.55d	39.07E
Calcium nitrate 1000 ppm	50.44hi	72.24bc	61.34B	53.74c	52.47c	53.11A
Salicylic acid 100 ppm	55.62f-h	81.51a	68.57A	30.96f	60.65b	45.81CD
Salicylic acid 50 ppm	58.62ef	77.02ab	67.82A	31.12f	58.63b	44.88D
Naphthalene acetic acid 100 ppm	58.50ef	55.99fg	57.25C	36.17ef	65.66a	50.92AB
Naphthalene acetic acid 50 ppm	56.72f	62.92de	59.82BC	31.37f	66.99a	49.18BC
Mean	52.49B	66.37A		36.73B	55.38A	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Flowering and Fruit Setting:

Flowering Density (Average No. of Inflorescences/m): The effect of treatments and cultivars on flowering density in 2017 and 2018 seasons is shown in Table (11). In 2017 season, both Salicylic acid treatments recorded higher values (68.57 and 67.82 inflorescences/m, respectively). In 2018 season, Calcium nitrate (1000 ppm) treatment proved to be the best in this regard (53.11 inflorescences/m). In both seasons, Potassium silicate (1000 ppm) treatment gave the lowest values. Picual significantly surpassed Manzanillo in both seasons. Using Salicylic acid (100 ppm) treatment with Picual recorded the best value (81.51 inflorescences/m), while using control treatment with Manzanillo gave the lowest value in the 1st season. In the 2nd season, NAA (100 and 50 ppm) treatments with Picual gave higher values (65.66 and 66.99 inflorescences/m, respectively), whereas lowest value was recorded when spraying Manzanillo with Salicylic acid (100 ppm). Salinity reduced flowering density [6]. It was found that using Salicylic acid improved flowering density [20, 6, 30]. NAA effects might be due to canopy internal hormonal and carbohydrate level improvement, which is responsible for improving number of inflorescence [55]. Goargious *et al*. [43] reported statistically higher flowering density of Picual than Manzanillo in 2014 season.

Perfect Flower Percentage: Table (12) shows the effect of treatments and olive cultivars on perfect flower percentage. Data demonstrate that in both seasons NAA (50 ppm) proved to be significantly the best treatment in this regard (69.79 and 78.67%, respectively). Control treatment gave the lowest values. Picual exceeded Manzanillo in 2017 season but in 2018 season, the two cultivars switched their positions with significant differences. The interaction cleared that in the 1st season, spraying Picual with NAA (50 ppm) recorded the highest percentage (79.91%) while in the 2nd season, spraying Manzanillo with Salicylic acid (50 ppm) treatment showed the highest percentage (84.91%). Control treatment with Manzanillo in the 1st season and with Picual in the 2nd season gave significantly the lowest percentages in this concern.

In this study decreased leaf moisture percentage due to salinity was accompanied by a decrease in the percentage of perfect flowers in control treatment in both seasons. Therios and Misopolinos [44] mentioned that salinity reduced the number of perfect flowers/ inflorescence. Abd-El-Rhman and Attia [6] found that salinity reduced sex ratio. Perfect flower percentage of Aggezi Shami and Picual olive trees was increased using Salicylic acid as reported by Abd El-Razek *et al*. [20] and Abd-Alhamid *et al*. [56], respectively. Number of perfect flowers was improved using Salicylic acid and Naphthalene acetic acid than the control treatment [57]. Picual recorded a higher significant perfect flower percentage than Manzanillo and spraying Picual with Salicylic acid 200 ppm gave the highest perfect flower percentage [42, 30].

Final Fruit Set Percentage: As shown in Table (13), in both seasons, Salicylic acid (50 ppm) and Potassium silicate (1000 ppm) treatments recorded higher values (4.20 and 4.13 % in 2017 as well as 6.77 and 7.01% in 2018, respectively). The lowest percentages were given by Calcium nitrate (2000 ppm) in both seasons. Significant differences were observed showing that Picual surpassed Manzanillo just in 2017 season, while in 2018 they switched their positions. Spraying Picual with Salicylic acid (50 ppm) treatment in the 1st season and Manzanillo in the 2nd season surpassed the others (5.41 and 8.05 %, respectively). The lowest values were presented by control treatment with Manzanillo in both seasons. Salinity reduced fruit set and using Salicylic acid increased Manzanillo fruit set percentage in both seasons. This increase was attributed to increased total chlorophyll content which leads to production of more carbohydrates through photosynthesis process [44, 6]. Using Salicylic acid enhanced fruit set as reported by Abdel Aziz *et al*. [21] on pomegranate trees (Manfalouty), Abd-Alhamid *et al*. [56] on Picual trees and Lenka *et al*. [22] on guava (Allahabad Safeda). Foliar application with K_2SO_4 (3%) improved fruit set of Koroneiki olives [58]. Abo-El-Ez *et al*. [30] reported that Picual was significantly superior in final fruit set than Manzanillo and they also found that NAA (50 and 100 ppm) and Salicylic acid (200 and 400 ppm) showed higher values when applied to Picual in 2015 season.

Fruit Retention Percentage: Data tabulated in Table (14) show that using of Salicylic acid (50 ppm) and Potassium silicate (1000 ppm) pronounced fruit retention in 2017 and 2018 seasons, respectively. Minimum fruit retention percentage was significantly recorded by Calcium nitrate (2000 ppm) in both seasons. In 2018 season, Manzanillo surpassed with a significant difference. Spraying Picual with Salicylic acid (50 ppm) in 2017 season and spraying Manzanillo with Potassium silicate (1000 ppm) and Salicylic acid (100 ppm) in 2018 season resulted in improved fruit retention percentages. However, using Calcium nitrate (2000 ppm) with Manzanillo and Picual took the other way around in 2017 and 2018, respectively. Different concentrations and frequencies of Potassium silicate were useful in Keitte mango fruit retention [59]. Mahmoud *et al*. [58] concluded that spraying Koroneiki with K increased fruit retention. Salicylic acid was beneficial in fruit retention of pomegranate trees [21].

Fresh Fruit and Pulp Weight (G): Tables (15) and (16) present the effect of treatments and olive cultivars on fresh fruit and pulp weight, respectively in 2017 and 2018 seasons. Improved fresh fruit and pulp weight (g) were estimated by Salicylic acid (100 ppm), whereas lesser values were shown by Potassium silicate (500 ppm) in both seasons regarding pulp weight and just in 2017 season as well as by control treatment in 2018 season

Table 12: The effect of treatments and olive cultivars on perfect flower percentage in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	--------------- 2017	------------		--------------- 2018	-----------	
Control	16.00g	54.05ef	35.03E	46.82i	22.61k	34.71F
Potassium silicate 1000 ppm	54.07ef	78.10a	66.08BC	60.78fg	67.49d	64.14C
Potassium silicate 500 ppm	56.42c-f	77.27a	66.85A-C	67.12de	40.89j	54.00E
Calcium nitrate 2000 ppm	56.32c-f	60.68c	58.50D	69.14cd	56.44gh	62.79C
Calcium nitrate 1000 ppm	54.67d-f	75.87a	65.27BC	62.80ef	53.36h	58.08D
Salicylic acid 100 ppm	52.97f	75.13a	64.05C	60.57fg	66.79de	63.68C
Salicylic acid 50 ppm	69.51b	66.30b	67.91AB	84.91a	59.32fg	72.11B
Naphthalene acetic acid 100 ppm	58.43c-e	61.23c	59.83D	71.99c	58.29fg	65.14C
Naphthalene acetic acid 50 ppm	59.67cd	79.91a	69.79A	80.85a	76.50b	78.67A
Mean	53.12B	69.84A		67.22A	55.74B	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Table 13: The effect of treatments and olive cultivars on final fruit set percentage in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	--------------- 2017	------------		--------------- 2018	-----------	
Control	2.18h	4.81b	3.49B-D	2.87h	5.07de	3.97EF
Potassium silicate 1000 ppm	3.72c-e	4.54b	4.13A	6.17c	7.84ab	7.01A
Potassium silicate 500 ppm	3.13e-g	4.40b	3.77A-C	3.66g	6.16c	4.91C
Calcium nitrate 2000 ppm	2.26h	3.76c-e	3.01E	3.66g	4.09fg	3.88F
Calcium nitrate 1000 ppm	3.53ef	4.32bc	3.92AB	4.18fg	4.83e	4.50D
Salicylic acid 100 ppm	2.98fg	3.61d-f	3.30DE	7.36b	3.02h	5.19C
Salicylic acid 50 ppm	2.99fg	5.41a	4.20A	8.05a	5.49d	6.77A
Naphthalene acetic acid 100 ppm	2.58gh	4.25b-d	3.42C-E	3.93g	4.65ef	4.29DE
Naphthalene acetic acid 50 ppm	3.75c-e	4.44b	4.09A	7.30b	3.96g	5.63B
Mean	3.01B	4.39A		5.24A	5.01B	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Table 14: The effect of treatments and olive cultivars on fruit retention percentage in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	--------------- 2017	------------		--------------- 2018	-----------	
Control	49.22e	45.00g	47.11D	50.63g	45.25i	47.94F
Potassium silicate 1000 ppm	42.51j	49.01e	45.76EF	74.06a	54.39e	64.23A
Potassium silicate 500 ppm	53.81c	43.95h	48.88C	56.64d	34.67l	45.66G
Calcium nitrate 2000 ppm	35.25k	44.22gh	39.74H	52.08f	28.63n	40.36I
Calcium nitrate 1000 ppm	47.89f	42.82ij	45.35F	62.50c	41.64j	52.07D
Salicylic acid 100 ppm	43.25h-j	43.65hi	43.45G	74.60a	32.89m	53.74C
Salicylic acid 50 ppm	52.36d	56.75a	54.55A	61.71c	51.76f	56.74B
Naphthalene acetic acid 100 ppm	42.82ij	49.92e	46.37E	49.05h	36.82k	42.93H
Naphthalene acetic acid 50 ppm	55.32b	45.17g	50.24B	69.05b	32.58m	50.82E
Mean	46.94A	46.72A		61.15A	39.85B	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

concerning fruit weight. Manzanillo scored the highest significant values of fresh fruit and pulp weight in both seasons. Spraying Manzanillo with Calcium nitrate (1000 ppm) recorded higher values in the respect of fruit and pulp weight. Treating Picual with Potassium silicate (500 ppm) and Calcium nitrate (2000 ppm) resulted in minimum values in 2017 and 2018 seasons, respectively.

Salinity stress decreased olive fruit weight [12, 14, 16, 6, 17]. Khalil *et al.* [57] found that Salicylic acid improved fruit weight. Moreover, Abd El-Razek *et al.* [20] and Abd-El-Rhman and Attia [6] concluded that Salicylic acid treatments enhanced fruit weight. Also, it increased pulp weight on different olive cultivars [57, 20, 30, 23]. Osman [60] noted that spraying NAA (150 ppm) 15 days

Table 15: The effect of treatments and olive cultivars on fresh fruit weight (g) in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	------------- 2017	-----------		-------------- 2018	----------	
Control	3.980d	3.131i	3.555E	3.978h-j	3.895j	3.937G
Potassium silicate 1000 ppm	3.774e	3.079i	3.427F	4.275g	3.795k	4.035F
Potassium silicate 500 ppm	4.000d	2.496k	3.248G	4.058h	3.963ij	4.010F
Calcium nitrate 2000 ppm	4.118c	2.977j	3.548E	5.038b	3.373l	4.206E
Calcium nitrate 1000 ppm	4.433a	3.633f	4.033A	5.335a	4.012hi	4.674B
Salicylic acid 100 ppm	4.310b	3.695f	4.003AB	5.038b	4.908c	4.973A
Salicylic acid 50 ppm	3.980d	3.263h	3.622D	5.050b	4.020hi	4.535C
Naphthalene acetic acid 100 ppm	4.358b	3.496g	3.927C	4.620e	4.222g	4.421D
Naphthalene acetic acid 50 ppm	4.308b	3.634f	3.971BC	4.751d	4.520f	4.635B
Mean	4.140A	3.267B		4.682A	4.079B	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Table 16: The effect of treatments and olive cultivars on fresh pulp weight (g) in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	------------- 2017	-----------		-------------- 2018	----------	
Control	3.297b-e	2.504h	2.901BC	3.333e-g	3.298e-g	3.316D
Potassium silicate 1000 ppm	3.149c-f	2.426h	2.788BC	3.590d-f	3.087g	3.339D
Potassium silicate 500 ppm	3.387b-d	1.963i	2.675C	3.384e-g	3.175fg	3.280D
Calcium nitrate 2000 ppm	3.474a-c	2.381h	2.928BC	4.319ab	2.660h	3.490CD
Calcium nitrate 1000 ppm	3.767a	2.915fg	3.341A	4.518a	3.273fg	3.896B
Salicylic acid 100 ppm	3.627ab	3.004ef	3.316A	4.342ab	4.153a-c	4.248A
Salicylic acid 50 ppm	3.341b-e	2.621gh	2.981B	4.227ab	3.317e-g	3.772BC
Naphthalene acetic acid 100 ppm	3.665ab	2.873fg	3.269A	3.938b-d	3.532d-g	3.735BC
Naphthalene acetic acid 50 ppm	3.599ab	3.027d-f	3.313A	4.083a-c	3.750c-e	3.917B
Mean	3.478A	2.635B		3.970A	3.361B	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Table 17: The effect of treatments and olive cultivars on yield (Kg) in 2017 and 2018 seasons

Treatments	Manzanillo	Picual	Mean	Manzanillo	Picual	Mean
	------------- 2017	-----------		-------------- 2018	----------	
Control	12.81j	14.50i	13.66G	1.33g	7.50d	4.42D
Potassium silicate 1000 ppm	20.00h	22.50g	21.25F	1.92g	3.40f	2.66E
Potassium silicate 500 ppm	25.00f	25.83f	25.42D	1.83g	2.33fg	2.08E
Calcium nitrate 2000 ppm	20.00h	33.33b	26.67C	1.58g	2.17g	1.88E
Calcium nitrate 1000 ppm	28.33e	31.67c	30.00A	1.75g	2.33fg	2.04E
Salicylic acid 100 ppm	25.00f	30.33d	27.67B	3.36f	8.25cd	5.81C
Salicylic acid 50 ppm	22.50g	35.83a	29.17A	5.33e	11.83b	8.58B
Naphthalene acetic acid 100 ppm	22.50g	22.50g	22.50E	5.20e	14.75a	9.98A
Naphthalene acetic acid 50 ppm	28.00e	27.85e	27.93B	9.20c	11.00b	10.10A
Mean	22.68B	27.15A		3.50B	7.06A	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

after full bloom increased significantly Dolce fruit flesh weight. Çiğdem *et al*. [61] stated that effects of NAA on fruit dimensions appear to be depending on the olive cultivar. Using $CaCl_2$ with irrigation water significantly improved fruit weight of Manzanillo trees under salinity conditions [15]. Treating Picual trees with $CaCO_3$ increased fruit and flesh weight [62]. Using calcium treatments improved Sultani fig cv. flesh weight under saline conditions [63]. Picual fruit weight is medium whilst Manzanillo is medium to high [17]. Abo-El-Ez *et al*. [30] reported that Manzanillo achieved higher fruit and flesh weight than Picual in the 1st and 3rd seasons with insignificant differences. Also, they added that treating Manzanillo with Salicylic acid 200 ppm in all studied seasons increased flesh weight. In this study, fruit weight was lower in 2017 season than 2018 season due to the higher crop load, Martín-Vertedor *et al*. [64] reported similar result.

Yield (Kg): Table (17) shows the effect of treatments and olive cultivars on yield in 2017 and 2018 seasons. It's worthy to mention that in 2018 season, high temperature prevailing at the floral initiation period of olive trees resulted in reduced yield (Fig. 1). Similarly, Elsayed [65] reported that Picual trees gave inferior yield in 2018 season due to the deleterious effect of high temperature on flowering and yield. Calcium nitrate (1000 ppm) and Salicylic acid (50 ppm) treatments recorded higher yield in the 1st season (30.00 and 29.17 Kg, respectively), while both NAA (100 and 50 ppm) treatments were the best in the 2nd season (9.98 and 10.10 Kg, respectively). The lowest yield was given by control treatment in 2017 season, but in 2018 season, both concentrations of Potassium silicate and Calcium nitrate treatments showed reduced yield. It is notable that the responsibility for increasing yield by Calcium nitrate (1000 ppm) treatment was because of increased fruit set (Table 13), fruit weight (Table 15) and pulp weight (Table 16) and by Salicylic acid (50 ppm) was due to the increase of fruit set percentage (Table 13) and pulp weight (Table 16) just in 2017 season. Picual significantly surpassed Manzanillo in both seasons. The best yield was significantly recorded by spraying Picual with Salicylic acid (50 ppm) treatment (35.83 Kg) in the 1st season and by NAA (100 ppm) treatment in the 2nd season (14.75 Kg). Lower yield was shown by using control treatments with Manzanillo in both seasons. It is generally accepted that high salinity reduces olive yield [11-16, 6, 17]. Using Salicylic acid treatments resulted in increasing yield of Egazy Shami, Manzanillo, Cobrançosa, guava and Picual trees [20, 6, 66, 22, 23]. Also, NAA treatments influenced yield [60, 62, 61, 22]. Abo-El-Ez *et al*. [30] found that yield of Picual trees insignificantly exceeded that of Manzanillo trees and they also found that the highest significant yield was given by application of Salicylic acid 200 ppm to Picual trees in 2016 season.

Results of improved yield in comparison with control treatment may be influenced by increase of water uptake (higher leaf water content percentage), enhanced leaf area and availability of nutrients. Also, the estimated results indicate that the positive effect of improving perfect flower percentage by both Salicylic acid and NAA (50 ppm) and final fruit set of Salicylic acid (50 ppm) resulted in increased yield than control trees.

Fruit Moisture and Oil Content Percentages

Fruit Moisture Content Percentage: Table (18) presents the effects of treatments and olive cultivars on fruit moisture percentage in 2017 and 2018 seasons. Minimum fruit moisture content was acquired by Salicylic acid (100 and 50 ppm) treatments, while Potassium silicate (1000 and 500 ppm), Calcium nitrate (2000 ppm), control and NAA (50 ppm) treatments showed higher content in both seasons. During the two studied seasons, Picual significantly recorded lesser values (67.06 and 66.80 %, respectively) than Manzanillo. Results proved that minimum values were given by NAA (100 ppm) when applied to Picual (65.14 and 64.90 %, respectively) whereas control and both concentrations of Potassium silicate treatments application to Manzanillo recorded higher values in both seasons.

Salinity increases fruits moisture content [12, 14]. The above results are in line with Abo-El-Ez *et al*. [30] who declared that Salicylic acid treatments recorded the lowest moisture content and he also mentioned that spraying Manzanillo trees with control treatment recorded higher moisture percentage. Similarly, Picual trees showed higher fruit moisture content when treated with $CaCO_3$ [62]. Similar result was obtained by Saad El-Din *et al*. [42], El-Khawaga and Maklad [67], Goargiuos *et al*. [43] and Abo-El-Ez *et al*. [30] who noticed that Picual gave lower significant fruit moisture values comparing to Manzanillo. Rosecrance *et al*. [68] found that fruit moisture levels below 50% and about 60% make oil extraction difficult. In this study, all the obtained moisture percentages are not within the previously mentioned range.

Oil Content Percentage: Data in Table (19) show the effect of treatments and olive cultivars on oil percentage (dry matter) in both seasons of study. NAA (50 ppm) treatment proved to be the best in this concern (28.79 %) in the 1st season. Salicylic acid and NAA (100 ppm) treatments recorded higher values in this concern (30.85 and 30.71 %, respectively) in the 2nd season. Control treatments significantly showed the minimum oil content in both seasons. During the two studied seasons, Picual achieved significantly higher oil content values (27.45 and 30.75, respectively). Spraying NAA (50 ppm) treatment in 2017 and NAA (100 ppm) in 2018 on Picual gave the highest significant values (31.88 and 34.07 %, respectively), while control treatment in both seasons when applied to Manzanillo took the other way around in both seasons.

In both seasons, the applied treatments showed significantly higher oil content than control treatment, similarly Chartzoulakis [12, 14], Tabatabaei [69], Abd-El-Rhman and Attia [6] and Kailis [17] reported that salinity reduces oil content. In the same direction, it was noted that all the applied treatments resulted in higher oil

Table 18: The effect of treatments and olive cultivars on fruit moisture percentage in 2017 and 2018 seasons

Treatments	Manzanillo --------------- 2017	Picual ------------	Mean	Manzanillo --------------- 2018	Picual -----------	Mean
Control	70.12a	65.93ef	68.03AB	69.57a	65.84de	67.71AB
Potassium silicate 1000 ppm	70.31a	67.89b-e	69.10A	68.77ab	67.17b-d	67.97AB
Potassium silicate 500 ppm	69.78ab	68.26a-d	69.02A	69.07ab	68.04a-c	68.56A
Calcium nitrate 2000 ppm	68.49a-c	68.90a-c	68.70A	68.19a-c	68.75ab	68.47A
Calcium nitrate 1000 ppm	67.33c-e	67.21c-f	67.27BC	67.07b-d	67.08b-d	67.08BC
Salicylic acid 100 ppm	66.33d-f	65.92ef	66.13C	65.81de	65.86de	65.84C
Salicylic acid 50 ppm	67.02c-f	65.77ef	66.40C	66.63c-e	65.55de	66.09C
Naphthalene acetic acid 100 ppm	68.71a-c	65.14f	66.93BC	68.60a-c	64.90e	66.75BC
Naphthalene acetic acid 50 ppm	67.79b-e	68.51a-c	68.15AB	67.49b-d	68.05a-c	67.77AB
Mean	68.43A	67.06B		67.91A	66.80B	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

Table 19: The effect of treatments and olive cultivars on oil content percentage (dry matter) in 2017 and 2018 seasons

Treatments	Manzanillo --------------- 2017	Picual ------------	Mean	Manzanillo --------------- 2018	Picual -----------	Mean
Control	18.25j	25.36e	21.80H	24.64k	29.11gh	26.88E
Potassium silicate 1000 ppm	22.91g	29.27b	26.09C	28.65h	31.50bc	30.07B
Potassium silicate 500 ppm	24.10f	21.56h	22.83G	25.89j	29.20gh	27.55D
Calcium nitrate 2000 ppm	23.23g	25.84de	24.53DE	29.56fg	28.88gh	29.22C
Calcium nitrate 1000 ppm	20.35i	27.77c	24.06E	28.79gh	30.48de	29.64BC
Salicylic acid 100 ppm	20.36i	29.58b	24.97D	30.48de	31.22cd	30.85A
Salicylic acid 50 ppm	20.55i	26.44d	23.50F	25.38jk	30.16ef	27.77D
Naphthalene acetic acid 100 ppm	25.57e	29.40b	27.49B	27.36i	34.07a	30.71A
Naphthalene acetic acid 50 ppm	25.71de	31.88a	28.79A	27.63i	32.14b	29.88B
Mean	22.34B	27.45A		27.60B	30.75A	

Means designated with the same letter within columns and rows in each season are not significantly different according to Duncan's Multiple Range Test (DMRT) at 0.05 level of probability

content than control treatment [57, 20, 70, 6, 30]. Osman [60] found that applying NAA (150 ppm) to Dolce trees resulted in increased oil content in 2012 season. Using Salicylic acid treatments on Picual trees resulted in higher oil content percentage [30]. The above results are in agreement with the authors who reported that Picual oil content significantly surpassed Manzanillo in the studied seasons [67, 43, 30]. In this study, oil content was lower in 2017 season than 2018 season due to the higher crop load, Martín-Vertedor *et al*. [64] reported similar result.

In the present study, application of Salicylic acid (100 and 50 ppm) treatment and NAA (100 ppm) treatment on Picual resulted in lowest fruit moisture percentages (Table 18) and these results may have an applicable advantage in improving olive oil extraction and phenolic transfer yields [71]. Talhaoui *et al*. [72] found that phenolic compounds are responsible for the nutritional and sensory quality of extra-virgin olive oil. Picual and Koroneiki showed the highest transfer rates (1.85% and 1.95%) and the lowest fruit moisture (62% for both). They highlighted the influence of the genetic factor in the phenolic compounds transfer from olive fruit to oil. Also, Vossen [73] reported that it is difficult to extract the oil from over-irrigated fruit and has a high moisture content due to the formation of an emulsion (watery gel) between oil and water that escapes with the fruit-water or pomace solids. In this study, Picual showed lowest fruit moisture content percentage (Table 18), so the oil extraction of its fruits will be easier than Manzanillo fruits with lesser oil loss and with the highest transfer rates of phenolic compounds. Taking into consideration that Picual maximum oil content percentage (Table 19) and irrigation with saline water increased the contents of total phenols and major phenols in olive oil as previously reported by Ben Ahmed *et al.* [74] and Stefanoudaki *et al.* [75] the resulted final product is a respectable amount of extra virgin olive oil.

CONCLUSION

It may be concluded that applying NAA (50 ppm) increased leaf area, perfect flower percentage, yield and oil content of Picual and Manzanillo trees irrigated with saline ground water (EC 7.06 dSm^{-1}/5648 ppm).

Also, Picual achieved higher yield and oil content than Manzanillo and was more tolerant when was irrigated with saline water. It's recommended to apply NAA (50 ppm) foliar application in mid-February to increase yield and oil percentage.

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