ALEXANDRIA

SCIENCE EXCHANGE JOURNAL

Vol. 44 APRIL- JUNE 2023

Effect of Pre-Harvest Sprays with Calcium and Ascorbic Acid on Fruit Quality of Olive

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ABSTRACT

The trial was conducted through 2017, 2018 and 2019 seasons on 9 years old "Kalamata" olives cultivated at 5×5 m apart in sandy soil. Trees were irrigated from a well using a drip irrigation system. To investigate the effects of calcium chloride and ascorbic acid as foliar spray Firstly: on yield and fruit quality, Secondly: on the next flowering, fruit set of "Kalamata" olive trees.

Sprayed "Kalamata" olive trees with calcium chloride at (1.0 and 1.5%), ascorbic acid at (1500 and 2000 ppm) and calcium chloride at 1.5% combined with ascorbic acid at 2000 ppm were carried out at three times, in mid- May (end of fruit set), in mid-June (during pit hardening) and in performed second week of October.

The results revealed that calcium chloride and ascorbic acid foliar spray induced a positive effect on leaf chlorophyll and calcium content, yield, biennial bearing index, fruit quality i.e. pulp thickness and pulp oil content as compared with control treatment of "Kalamata" olive. They also improved the next flowering; number of panicle/shoot, number of total flowers/ panicle, fruit set compared to untreated trees.

Briefly, foliar spray "Kalamata" olive trees with calcium chloride at 1.5% plus ascorbic acid at 2000 ppm at three times during fruit development was able to improve yield and fruit quality also, it enhanced the next flowering and fruit set.

Keyword: Calcium; Ascorbic; Yield; Quality; Flowering.

INTRODUCTION

Olive is the one of the oldest cultivated fruits in Egypt, it plays an important role; it is a part of the social and culture tradition of some regions of Egypt especially in Siwa oasis at Matrouh governorate (Hedia and Abd Elkawy, 2016).

In Siwa oasis, many olive varieties cultivated for oil or pickling. "Kalamata" olive is mainly cultivated for pickling. Hand pickling is the most common harvest method used in Siwa oasis.

Traditionally, the olives harvesting is performed by hand (Ferguson, 2006 and Jiménez *et al.*, 2017).

During the olive harvested, fruits damage may occur, that commonly called bruising, and that is may probably related to shake shoots and small brushes to remove fruits during harvested (Castro-García *et al.*, 2015).

Bruising leads to dark spots appear on fruit pulp after harvest (Castro-García *et al.*, 2010 and Jiménez *et al.*, 2016), and fruit value decreases particularly in table olive consumption (Riquelme *et al.*, 2008).

According to Hammami and Rapoport (2012) mentioned that susceptibility to bruise may be related to the pulp thickness in olive cultivars. Connor *et al.* (2014) confirmed that the olive pulp thickness is related to the level of fruit mechanical damage.

Vichi *et al.* (2016) revealed that both the olive pulp thickness had associated to protection from biotic and abiotic external factors.

On the other hand, the loss of quality in the extracted oils and internal damage could be attributed to various fruits physiological responses after harvest (Yousfi *et al.*, 2012; Morales-Sillero *et al.*, 2014; Morales-Sillero and García, 2015).

Olive pulp thickness and firmness are important key parameters for storage, and to transport olive crop from orchard to the main markets. Fruit quality count on many factors such as mineral nutrition. Trees and fruits mineral composition is related to postharvest disorders and decay (Dris & Niskanen, 1996; Bonomelli and Ruiz, 2010).

Calcium is a major plant nutrient, it is an essential element which affects growth, fruiting, and it maintenance of cell wall and improves postharvest

DOI: 10.21608/asejaiqjsae.2023.295812

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Received March 05, 2023, Accepted, April 18, 2023.

quality of fruits, and delays their senescence (Ferguson, 1984 and Gerasopulos *et al.*, 1996). Calcium enhances resistance to biotic and abiotic diseases (Yuen, 1993).

Tsantili *et al.* (2008) reported that calcium chloride spray three applications before harvested increased pulp of black-ripe 'Konservolia' olive. Morales-Sillero *et al.* (2020) confirmed that calcium foliar sprays before harvest increased pulp oil content (dry weight basis), in addition to reduction of physiological disorders of green table olives.

Calcium is an essential element for fruit quality (Conway *et al.*, 2001) Moreover, it increase olive quality and increased olive pulp oil content (dry weight basis). Calcium is considered an important factor in determining fruits quality storage (Raese *et al.*, 1990), it improved fruit quality and decreasing postharvest decay (Manganaris *et al.*, 2005). Hocking *et al.* (2016) reported that the mechanisms of calcium absorption, transport, and storage in the fruit and their impact on fruit quality during harvest and postharvest are still unclear.

In addition, calcium enhanced fruit set, fruit growth and maturation when foliar spray during pit hardening, it reduced fruit drop percentage as well as increased fruit weight and yield of "Manzanillo" olive trees (Mikhail and Goargios, 2014). Additionally, El‑Hady *et al.* (2020) mentioned that calcium chloride and/or chelated calcium foliar sprays at 0.5 % at the end of December improved fruit set, yield, fruit quality and oil content of "Kalmata" and "Manzanillo" olive trees. Moreover, Hagagg *et al*. (2020a) indicated that foliar sprays of 0.5% chelated calcium at the end of December enhance vegetative growth and its mineral contents of "Kalmata" and "Manzanillo" olive trees.

After absorption, calcium is primarily moved via xylem primarily to growing tissues, which is regulated by auxins presence in the apex and fruits seeds (Saure, 2005). So that in this research we apply ascorbic acid as foliar spray to help calcium movement in plant, whereas ascorbic acid utilized in place of synthetic auxins on Washington Novel orange (Ragab, 2002).

Shalata & Peter (2001) and Khan (2006) have suggested that ascorbic acid can be utilized as a possible growth regulator to increase stress tolerance in various species. It is an antioxidant that can catch any free radicals produced by plant metabolism thereby enhancing plant tolerance to stress. Furthermore, they offer enough protection from the harmful effects of activated oxygen species (Nicholas, 1996 and Alscher *et al.*, 1997).

Maksoud *et al*. (2009) reported that spraying ascorbic acid at concentrations of 1000 and 2000 ppm improved olive yield and fruit quality. Yousef *et al.* (2009) mentioned that 90ml/l ascorbic acid foliar spray before harvest enhanced fruit chemical characteristics also, had a positive effect on "Picaul" olive oil components. Additionally, El-Sayed *et al*. (2014) mentioned that ascorbic acid enhanced growth, fruit set and yield as well as fruit quality of 'Manzanillo" olive trees treated.

The purpose of this work aimed to study the effects of calcium chloride and ascorbic acid foliar spray, Firstly: on yield and fruit quality, Secondly: on next flowering and fruit set of "Kalamata" olive trees.

MATERIALS AND METHODS

This investigation was conducted on nine years old of Kalamata olive cv. grown in a private orchard in Siwa oasis, Matrouh governorate, Egypt, during three successive seasons 2017, 2018 and 2019.

Trees nearly uniform in vigor growth and planted 5 x 5 meters apart, in sandy soil under drip irrigation system from a well and obtained the regular horticultural practices. Soil analysis of experimental orchard and irrigation water were analyzed and presented in Tables (1 and 2).

Table 1. Analysis of soil in 2017 and 2018 seasons

Soil Depth cm	Sand (%)	Silt (%)	Clay (%)	Texture Class	pH Soil past	E.Ce (dSm^{-1})	Soluble cations (meq/l)				soluble anions (meq/l)			
							Ca^{++}	K^{+}	Na^{+}	Mg^{++}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	$CO_3^{=}$
0-30	90.70	6.35	2.95	sandy	7.6	1.4	3.2	1.7	9.1	1.5	9.0	5.5	1.0	-
30-60	91.75	5.6	2.65	sandy	7.6	1.3	2.5	1.7	10.0	1.5	9.0	5.5	1.2	-

Table 2. Chemical analysis of water for irrigation in 2017 and 2018 seasons

pH	E.C. dSm^{-1}	Soluble cations (meq/l)				soluble anions (meq/l)			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
7.00	1.1	0.8	0.7	7	0.4	0	1.8	7	0.1

Thirty six healthy trees, which were nearly uniform in shape and size and productivity and obtained the same horticulture practices, were subjected to six treatments as foliar sprays:

1.Control tap water
2.Calcium chloride ($CaCl_2$, 21% Ca) at 1.0 %
3.Calcium chloride ($CaCl_2$) at 1.5 %
4.Ascorbic acid (AsA) at 1500 ppm
5.Ascorbic acid (AsA) at 2000 ppm
6.Calcium chloride ($CaCl_2$) at 1.5 % + ascorbic acid (AsA) at 2000 ppm (chemicals mixed done before foliar spray directly).

The experiment was conducted using a randomized complete block design with three replicates for each treatment and each replicate was represented by two trees.

Foliar sprays of calcium chloride ($CaCl_2$) and ascorbic acid (AsA) treatments were carried out at three times i.e., the first foliar sprays was done in mid- May (end of fruit set), the second one was done in mid-June (during pit hardening) and the third one was done in performed second week of October. Tween-20 was added at a concentration of 0.1% as a surfactant to all spray solutions, including the control "tap water". Spraying was performed using compression sprayers (6L solution/tree) at the previously mentioned dates.

On the other hand, the control trees were sprayed with tap water at the previously mentioned times. The response of Kalamata olive trees to the tested calcium chloride ($CaCl_2$) and ascorbic acid (AsA) treatments were evaluated through the following determinations.

Leaf characteristics

The total chlorophyll content in the leaves was measured using a Minolta chlorophyll meter SPAD-502. while leaf calcium content was determined; samples were collected at the end of each growing season during fourth week of October, Whereas, two mature leaves (4^{th} and 5^{th}) per shoot were taken from one year old shoots mixed together washed with tap water followed by distilled water and dried in an electric oven at 70ºC till constant weight then they were ground, digested and prepared for analysis Parkinson and Allen (1975). Calcium was determined according to Chapman and Pratt (1961).

Yield

The average yield per tree (kg/tree) was recorded for each treatment at harvesting date (November, 1^{st}, 2017 season, and October, 26^{th}, 2018 season) for each treatment.

Biennial bearing index

It was calculated, according to Wilcox (1944) using the following formula: (Differences in yield between successive years / Sum of yield of successive years) x100.

Fruit physical and chemical properties

Representative fruit sample were taken at harvest (in 2017 and 2018 seasons, respectively) from each treated tree for measuring of the following physical parameters. Fruit weight (g), fruit (length and diameter cm), fruit volume (cm^3) and pulp thickness (cm). Fruits chemical properties were determine as following. Fruit moisture content was assessed from 50 g of fruits then dried in an oven at 80°C to a constant weight. Fruit oil content was determined by extracting dry material (50g) with 40-60ºC petroleum ether using a Soxhlet apparatus as described in the A.O.A.C. (1995). Acid value**;** 5 grams of oil were weighed in 250 ml dry conical flask with 100 of neutralized "50% ethanol + 50% petroleum ether" to dissolve the oil sample. Acid value was measuring by titration with 0.1 N potassium hydroxide solutions in of phenol phthalein presence as an indicator (A.O.A.C., 1995).

Flowering and fruit set:

The effect of tested calcium chloride ($CaCl_2$) and ascorbic acid (AsA) treatments on flowering and fruit set percentage of the following seasons (2018 and 2019, respectively) was investigated. Forty one year old shoots were selected and tagged at four main branches of the four tree directions. On each tagged shoot, the following parameters were measured at the full bloom stage (80% opened flowers), number of panicles/shoot, No. of flowers/panicles and No. of perfect flowers/panicles and perfect flowers percentage equaled (No. of perfect flowers/total No. of flowers x100). Moreover, the percentage of initial fruit set (three weeks after full bloom) equaled (initial No. of fruit setting /total No. of flowers at full bloom) x100).

Statistical analysis

Obtained data in 2017, 2018 and 2019 seasons were analyzed using the analysis of variance according to

Clarke and Kempson (1997). Means values were differentiated using Rang test at the 0.05 level (Duncan, 1955).

RESULTS AND DISCUSSION

Leaf characteristics

Leaf chlorophyll content:

Regarding to leaf chlorophyll content of "Kalamata" olive in Table (3) it could be noticed that, all tested treatments of calcium chloride and ascorbic acid gave high positive effect on leaf chlorophyll content during 2017 and 2018 seasons. Moreover, foliar sprayed of calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm achieved the highest values of leaf chlorophyll content record (81.76 and 79.00) against control treatment record (64.30 and 60.00) in the 2017 and 2018 seasons, respectively.

Leaf calcium content:

Table (3) demonstrates that in both seasons, all tested treatments improved leaf calcium content than control trees. Generally, results showed that calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment gave the highest leaf calcium content (1.26 and 1.24 %) compared to control which had smallest values (1.03 and 1.07 %) in first and second seasons respectively.

Obtained results concerning the effect of calcium chloride on leaf characteristics are in agreement with Hagagg *et al.* (2020a) revealed that foliar sprays of 0.5% chelated calcium at the end of December improve chlorophyll content and its mineral contents of Kalmata and Manzanillo olive trees. Morales-Sillero *et al.* (2020) pointed out calcium foliar sprays before harvest increased leaf calcium content of green table olives. In addition, Abd El-wahed *et al.* (2021) illustrated that calcium chloride foliar spray at 4% increased leaf area of "Wonderful" pomegranate. On contrast, Tsantili *et al.* (2008) calcium chloride foliar sprays increased did not affect calcium and chlorophyll concentration and photosynthesis rate of "Konservolia" olive.

The enhancement of leaf characters by calcium may be due to that calcium plays an important role in cell expansion and cell division, as well as it has numerous roles in plant physiology and necessary for vegetative development (Hepler, 2005 and Marschner, 2012). And calcium is important intracellular messenger, mediating responses of hormones, biotic and abiotic stress signals (Abou El Hassan and Husein, 2016). On the other hand, calcium stimulated root to mineral uptake (Adamec, 2002). All of these reflected on improve total chlorophyll and leaf calcium content of olive trees.

Obtained results concerning the effect of ascorbic acid on leaf characteristics go in line with Aliniaeifard *et al.* (2008), they mentioned that the ascorbic acid foliar sprays has a great effect on chlorophyll of olive trees. Moreover, Ibrahim (2013) mentioned that ascorbic acid treatment at 750 mg/l increased leaves (area and total chlorophyll content) of olive trees. Al-Atrushy and Abdul-Qader (2016) found that ascorbic acid foliar spray at 400 mg/l (first two week after growth began, second month later) gave high values of leaf chlorophyll content of olive trees. Moreover, El Refae *et al.* (2022) indicated that ascorbic acid foliar spray had a positive effect on leaf chlorophyll content and leaf calcium content of "Picual" olive trees.

The improvement of ascorbic acid on leaf characteristics may be due to that fact ascorbic acid regulated cell division and cell expansion (Mohamed *et al.*, 2020). Ascorbic acid can prevent chlorophyll degradation, deactivate superoxide radicals, and indirectly increase the amount of chlorophyll in leaves (Bybordi, 2012). Also, it has auxinic function and effective role in the biosynthesis of carbohydrates. For these reason, all of these reflected on improved mineral uptake by roots lead to increase leaf calcium and chlorophyll content.

Table 3. Effect of calcium chloride ($CaCl_2$) and ascorbic acid (AsA) rates as foliar sprays on leaf chlorophyll content, leaf calcium content and yield of "Kalamata" olive trees (2017 and 2018 seasons)

Treatments	Leaf chlorophyll content		Leaf calcium content (%)		Yield (kg/tree)	
	2017	2018	2017	2018	2017	2018
Control	64.30 D	60.00 E	1.03 E	1.07 E	36.67 D	21.00 E
$CaCl_2$ at 1.0 %	67.83 CD	65.67 D	1.11 D	1.14 C	39.51 C	24.00 D
$CaCl_2$ at 1.5 %	68.31 CD	67.66 D	1.21 AB	1.19 B	39.70 C	25.50 CD
AsA at 1500 ppm	70.16 C	72.67 C	1.15 CD	1.12 D	42.20 B	27.13 BC
AsA at 2000 ppm	76.03 B	75.00 B	1.20 BC	1.18 B	43.16 AB	28.23 AB
$CaCl_2$ at 1.5 % + AsA at 2000 ppm	81.76 A	79.00 A	1.26 A	1.24 A	45.00 A	30.20 A

Means followed by the same letter(s) within each column are not significantly different at 5% level.

Table 4. Effect of calcium chloride ($CaCl_2$) and ascorbic acid (AsA) rates on (biennial bearing index) of "Kalamata" olive trees (2017 and 2018 seasons)

Treatments	Biennial bearing index
Control	27.17 A
$CaCl_2$ at 1.0 %	24.42 ABC
$CaCl_2$ at 1.5 %	24.79 AB
AsA at 1500 ppm	21.73 BCD
AsA at 2000 ppm	20.93 CD
$CaCl_2$ at 1.5 % + AsA at 2000 ppm	19.63 D

Means followed by the same letter(s) within each column are not significantly different at 5% level.

The results obtained concerning the effect of ascorbic acid plus calcium chloride treatment on leaf characteristics are in agreement with EL-Morsy *et al.* (2020) on potato and El-Eslamboly (2021) on sweet pepper.

The improvement of ascorbic acid plus calcium chloride treatment on leaf characteristics may be due to that fact of ascorbic acid as an antioxidant gave a positive effect on photosynthesis (Bybordi, 2012). On the other hand, calcium induced a positive effect on physiological processes in plants (Reddy & Reddy, 2001 and 2004).

Yield (kg)

It is clear from Table (3) that all treatments had a significant positive effect on yield compared to control in 2017 and 2018 seasons. Spraying of calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm was the most efficient treatment and record (45.00 and 30.20 kg/tree) against control (36.67 and 21.00 kg/tree) in both seasons, respectively. Spraying treatments of ascorbic acid at two rates and followed by calcium chloride at two rates gave an intermediate values in both seasons.

Biennial bearing index

Table (4) indicates that all tested calcium chloride and ascorbic acid foliar sprays gave a high positive effect in reducing biennial bearing index as compared with control treatment. Generally, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment was the most effective treatment in reduced biennial bearing index followed by ascorbic acid treatment at 2000 ppm in this concern. Calcium chloride at two rates gave an intermediate values in this concern.

The obtained results regarding effect of calcium chloride foliar spray on yield are in harmony with Mikhail and Goargios (2014) revealed that calcium treatment during pit hardening, has significantly increased yield of " Manzanillo" olive trees. Moreover, El- Hady *et al.* (2020) pointed out calcium chloride or chelated calcium foliar spray at 0.5 % at the end of December improved yield of "Kalmata" and "Manzanillo" olive trees.

The improvement in yield resulting from calcium chloride may be due to calcium plays a vital role in cell walls structure, cell membranes, fruit growth, and development (Kadir, 2004). And, calcium is an important for plant cell physiology, cell wall extension and stability and plasmalemma (Hawkesford *et al.*, 2012). Moreover the enhancement effect on chlorophyll content lead to more carbohydrates production that reflected to improved fruit yield of olive trees.

On the other hand, the obtained results concerning the effect of ascorbic acid on yield go in line with Maksoud *et al.* (2009) who mentioned that 1000 ppm ascorbic acid foliar spray in April, May, and June improved yield of "Chemlali" olive trees. Moreover, El-Sayed *et al.* (2014) reported that ascorbic acid increased yield of 'Manzanillo" olive.

The improvment effect of ascorbic acid on yield may be caused by ascorbic acid increased leaf chlorophyll content that reflected in induce more photosynthetic rates. This may be due to a high concentration of carbohydrates that induced increased cell division and growth, which led to trees producing an increased yield than untreated control trees.

The obtained results concerning the effect of ascorbic acid plus calcium chloride treatment on yield are in agreement with EL-Morsy *et al.* (2020) on potato and El-Eslamboly (2021) on sweet pepper.

The enhancement of ascorbic acid plus calcium chloride treatment on yield may be due to that fact calcium chloride induced a positive effect on cell walls and membranes, fruit growth, and development (Kadir, 2004 and Hawkesford *et al.*, 2012). Moreover, ascorbic acid has been suggested to have an auxinic function and effective role in the biosynthesis of carbohydrates (Shalata & Peter, 2001 and Khan, 2006). In addition, ascorbic acid help calcium movement in plant, whereas ascorbic acid used in place of artificial auxins on Washington Novel orange (Ragab, 2002). Moreover, the enhancement effect of ascorbic acid plus calcium chloride on leaf area, chlorophyll content and improved mineral uptake by roots lead to more carbohydrates production that reflected to improved yield of olive trees.

Fruit physical properties

Fruit weight (g)

It is clear from Table (5) illustrates that all calcium chloride and ascorbic acid succeeded in enhancing fruit weight compared to control in both seasons. Calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment and ascorbic acid at 2000 ppm gave a similar and the highest values of fruit weight in 2017 and 2018 seasons.

Fruit length (cm)

Table (5) illustrates that the tested calcium chloride and ascorbic acid treatments exerted an enhancement in fruit length compared to control in both seasons. Generally, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment exerted higher values of fruit length during 2017 seasons. Moreover, calcium chloride at 1.5 % plus 2000 ppm ascorbic acid treatment and 2000 ppm ascorbic acid induced a similar and the highest values of fruit length during 2018 seasons.

Fruit diameter (cm)

Table (5) indicates that all treatments had a significant enhancement in fruit diameter compared to control in 2017 and 2018 seasons. In generally, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment and 2000 ppm ascorbic acid gave a similar and greatest value of fruit diameter compared to other treatments in 2017 season in this concern. Moreover, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment improved fruit diameter as compared with other treatments in 2018 seasons.

Fruit volume (cm^3)

It is clear from Table (6) reveals that the tested calcium chloride and ascorbic acid treatments induced a significant positive effect on fruit volume compared to control treatment in both seasons, excepted 1.0 % calcium chloride treatment in 2017 season. Furthermore, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment and ascorbic acid at 2000 ppm treatment produced a similar and high significant value in improved fruit volume in 2017 season. However, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment showed superiority effect in enhancing fruit volume in 2018 season.

Table 5. Effect of calcium chloride ($CaCl_2$) and ascorbic acid (AsA) rates as foliar sprays on fruit weight and fruit (length and diameter) of "Kalamata" olive trees (2017 and 2018 seasons)

Treatments	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)	
	2017	2018	2017	2018	2017	2018
Control	5.61 C	5.71 C	2.30 D	2.23 C	1.69 D	1.72 E
$CaCl_2$ at 1.0 %	5.78 B	5.89 B	2.51 C	2.51 B	1.85 C	1.78 DE
$CaCl_2$ at 1.5 %	5.88 B	5.90 AB	2.63 B	2.54 B	1.89 BC	1.82 CD
AsA at 1500 ppm	5.94 B	5.96 A B	2.64 AB	2.59 B	1.98 AB	1.86 BC
AsA at 2000 ppm	6.46 A	6.01 A	2.68 AB	2.70 A	2.01 A	1.92 B
$CaCl_2$ at 1.5 % + AsA at 2000 ppm	6.68 A	6.02 A	2.75 A	2.77 A	2.06 A	2.04 A

Means followed by the same letter(s) within each column are not significantly different at 5% level.

Table 6. Effect of calcium chloride ($CaCl_2$) and ascorbic acid (AsA) rates as foliar sprays on fruit volume and pulp thickness of "Kalamata" olive trees (2017 and 2018 seasons)

Treatments	Fruit volume (cm^3)		pulp Thickness (cm)	
	2017	2018	2017	2018
Control	5.81 D	5.85 D	0.54 D	0.58 D
$CaCl_2$ at 1.0 %	5.84 D	5.96 C	0.59 CD	0.63 C
$CaCl_2$ at 1.5 %	6.02 C	5.99 BC	0.60 CD	0.64 BC
AsA at 1500 ppm	6.15 B	5.99 BC	0.63 BC	0.65 BC
AsA at 2000 ppm	6.47 A	6.03 B	0.69 AB	0.67 B
$CaCl_2$ at 1.5 % + AsA at 2000 ppm	6.54 A	6.10 A	0.71 A	0.72 A

Means followed by the same letter(s) within each column are not significantly different at 5% level.

Pulp Thickness (cm)

Table (6) indicates that all tested treatments induced high positive effect in improved pulp thickness in two seasons. Generally, 1.5 % calcium chloride plus ascorbic acid at 2000 ppm treatment produced a high positive effect in improving pulp thickness in 2017 and 2018 seasons.

Fruit chemical properties

Fruit moisture content (%)

Table (7) shows that all treatments pronounced a significant positive effect on fruit moisture content compared to control, except 1.0 % calcium chloride in both seasons and ascorbic acid at 1500 ppm in 2018 season. In general, calcium chloride at 1.5 % plus 2000 ppm ascorbic acid treatment and 2000 ppm ascorbic acid gave a similar and the highest values of fruit moisture content compared to other treatments in 2017 season. Furthermore, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment increased fruit moisture content percentage as compared with other treatments in 2018 seasons.

Fruit oil content (%)

Data present in Table (7) reveals that the tested calcium chloride and ascorbic acid treatments have a higher olive oil content percentage compared to control in 2017 and 2018 seasons, excepted calcium chloride at 1.0 % treatment in both seasons. Shortly, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment succeeded in increased fruit oil content percentage as compared with other treatments in 2017 and 2018 seasons.

Acidity

Table (7) indicates that all tested calcium chloride and ascorbic acid foliar spray induced reduction effect on acidity compared to the control treatment in both seasons. Generally, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment gave the highest reduction on acidity in 2017 and 2018 seasons.

The results obtained concerning the effect of calcium chloride on olive fruit quality and oil content go in line with Mikhail and Goargios (2014) they revealed that calcium treatment during pit hardening increased fruit weight of "Manzanillo" olive trees. El‐ Hady *et al.* (2020) pointed out calcium chloride or chelated calcium foliar spray at 0.5 % improved fruit quality and oil content of "Kalmata" and "Manzanillo" olive trees. Morales-Sillero *et al.* (2020) reaveals that calcium foliar sprays before harvest improved fruit quality, oil content and antioxidant content of "Manzanilla de Sevilla' and 'Ascolanta tenera" olives. Gouvinhas and Barros (2021) indicated that calcium application could be considered a good way to improve the quality of olive.

The enhancement of calcium chloride on fruit quality may be due to that calcium chloride improve leaf chlorophyll and calcium content which increased more carbohydrate production that reflected on improved fruit quality

The obtained results concerning the effect of ascorbic acid on fruit quality go in line with Maksoud *et al.* (2009) they reported that ascorbic acid application at 1000 and 2000 ppm improved fruit quality and flesh oils content of olive trees. El-Hosieny (2015) noticed that ascorbic acid foliar spray induced increased fruit weight, thickness, and pulp percentage of mango trees. Hagagg *et al.* (2020b) stated that ascorbic acid spraying improve fruit quality of "Picual" olive trees in both spraying dates (November and December). Al-Atrushy and Abdul-Qader (2016) found that foliar spray ascorbic acid at 400 mg/l increased physical and chemical fruits properties of olive trees.

Table 7. Effect of calcium chloride ($CaCl_2$) and ascorbic acid (AsA) rates as foliar sprays on fruit moisture content, fruit oil content and acidity of "Kalamata" olive trees (2017 and 2018 seasons)

Treatments	Moisture content (%)		Oil content (%)		Acidity	
	2017	2018	2017	2018	2017	2018
Control	53.63 B	52.38 C	37.47 C	37.49 C	0.91 A	0.90 A
$CaCl_2$ at 1.0 %	53.65 B	52.40 C	37.49 C	37.51 C	0.89 B	0.88 B
$CaCl_2$ at 1.5 %	54.55 AB	52.81 C	37.94 B	37.96 B	0.88 BC	0.87 BC
AsA at 1500 ppm	54.57 AB	52.84 BC	37.96 B	37.94 B	0.87 C	0.86 CD
AsA at 2000 ppm	55.45 A	54.10 AB	39.03 A	39.04 A	0.86 CD	0.86 CD
$CaCl_2$ at 1.5 % + AsA at 2000 ppm	55.47 A	54.13 A	39.11 A	39.47 A	0.85 D	0.84 D

Means followed by the same letter(s) within each column are not significantly different at 5% level.

The enhancement of ascorbic acid application on olive fruit quality may be caused by ascorbic like artificial auxin and it improves the fruit quality Ragab (2002) on Washington Novel orange. Furthermore, ascorbic acid as antioxidant catches free radicals and protects cells from oxidative stress that causes senescence (Karadeniz *et al.,* 2005). Moreover, the reasons for these results may be due to increasing growth as a result of foliar spray for ascorbic acid lead to increase leaf chlorophyll content, thus increasing photosynthesis which led to an increase in the fruit qualities (Abd El-Mageed, 2016).

The obtained results concerning the effect of ascorbic acid plus calcium chloride treatment on fruit quality are in agreement with El-Eslamboly (2021) on sweet pepper.

The enhancement of ascorbic acid plus calcium chloride treatment on yield may be due to that ascorbic acid plus calcium chloride resulted in enhanced leaf area, leaf chlorophyll content and it improved mineral uptake by roots that lead to give more carbohydrate production and that reflected on fruit quality.

Flowering and fruiting parameters during 2018 and 2019 seasons:

No. of panicles/shoot

Table (8) indicates that all tested calcium chloride and ascorbic acid foliar spray induced a significant positive effect on No. of panicles per shoot compared to the control in 2018 and 2019. Generally, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment gave the highest positive effect on number of panicles per shoot in 2018 and 2019 seasons. Moreover, ascorbic acid treatments had high number of panicles per shoot than calcium chloride treatments in 2018 and 2019 seasons.

No. of total flowers/panicle

Data recorded in Table (8) illustrates that calcium chloride and ascorbic acid foliar sprays enhanced number of flowers/panicle compared to the control in 2018 and 2019 seasons. Moreover, calcium chloride at 1.5 % plus 2000 ppm ascorbic acid foliar spray induced the highest positive effect on number of flowers/panicle in both seasons. Moreover, other foliar sprays gave an intermediate values.

Perfect flowers (%)

Table (8) reveals that all tested foliar spray gave similar and high values of perfect flowers percentage compared to the control treatment in 2018 and 2019 seasons. Generally, in the 2018 season, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment and ascorbic acid at two rates gave similar and the highest positive effect in this concern. However, in 2019 season, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm foliar spray was the most successful treatment.

Fruit set percentage

Table (8) that all studied treatments increased the percentage of fruit set of "Kalamata" olive trees compared to the control in 2018 and 2019 seasons. Moreover, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment and 2000 ppm ascorbic acid induced similar and high values of fruit set compared to other treatments in 2018 season. Furthermore, calcium chloride at 1.5 % plus ascorbic acid at 2000 ppm treatment shows superiority in 2019 season.

The obtained results concerning the effect of calcium chloride application on flowering and fruiting parameters go in line with Mikhail and Goargios (2014) on" Manzanillo" olive trees, they revealed that calcium play a significant role in fruit set and fruit development when calcium applied during pit hardening. Moreover, El- Hady *et al.* (2020) pointed out calcium chloride or chelated calcium foliar spray at 0.5 % at the end of December improved flowering, fruit set of "Kalmata" and "Manzanillo" olive trees.

Table 8. Effect of calcium chloride ($CaCl_2$) and ascorbic acid (AsA) rates as foliar sprays on flowering and fruit set of "Kalamata" olive trees (2018 and 2019 seasons)

Treatments	No. of panicles/shoot		No. of flowers/panicles		Perfect flowers (%)		Fruit set (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
Control	5.03 D	9.07 C	12.93 C	13.42 D	8.75 D	10.25 F	29.52 D	30.00 D
$CaCl_2$ at 1.0 %	5.69 C	9.46 B	13.15 BC	13.60 C	9.31 C	10.34 E	32.44 C	34.00 C
$CaCl_2$ at 1.5 %	5.95 BC	9.63 AB	13.21 AB	13.67 BC	10.15 B	11.30 C	34.55 B	36.60 BC
AsA at 1500 ppm	6.45 AB	9.53 B	13.23 AB	13.70 BC	10.52 A	10.92 D	35.70 AB	37.40 B
AsA at 2000 ppm	6.45 AB	9.54 B	13.27 AB	13.76 AB	10.56 A	11.39 B	36.40 A	38.50 AB
$CaCl_2$ at 1.5 % + AsA at 2000 ppm	6.69 A	9.90 A	13.42 A	13.83 A	10.69 A	11.56 A	37.00 A	41.00 A

Means followed by the same letter(s) within each column are not significantly different at 5% level.

The enhancement effect of calcium chloride application on flowering and fruiting parameters may be explained that calcium is important to regulate absorption other minerals to across plasma cell membranes. It is important to plant cell elongation, structure, division and cell membranes permeability. As a result, calcium is an essential factor in inflorescence and flower formation, as well as fruit set (Hepler and Winship, 2010).

The obtained results concerning the effect of ascorbic acid application on flowering and fruiting parameters go in line with Ezz (1999) on orange trees. Moreover, El-Sayed *et al.* (2014) mentioned that ascorbic acid foliar spray enhanced flowering and fruit set of "Manzanillo" olive trees.

The enhancement effect of ascorbic acid application on flowering and fruiting parameters may be explained that ascorbic acid ascorbic like artificial auxin Ragab (2002) on orange trees. That may be explaining the present results.

The enhancement of calcium chloride combined with ascorbic acid on flowering and fruit set may be due to that calcium chloride combined with ascorbic acid improved leaf chlorophyll and calcium content which increased more carbohydrate production, moreover, calcium is an essential to plant cell development and cell membranes permeability. And that is an important role to inflorescence and flowers formation and development (Hepler and Winship, 2010). In addition, ascorbic like artificial auxin Ragab (2002), furthermore, ascorbic acid help calcium movement in plant (Saure, 2005). All of these reflected in improved flowering and fruit set of olive trees.

CONCLUSION

It is suitable to foliar sprays "Kalamata" olive trees with (calcium chloride at 1.5% plus 2000 ppm ascorbic acid) at 3 times a year; first in mid- May (end of fruit set), second in mid-June (during pit hardening) and third in second week of October to improve yield, and fruit quality as well as it improved the next flowering and fruit set.

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الملخص العربي

تأثير الرش قبل الحصاد بالكالسيوم وحمض الأسكوربيك على جودة ثمار الزيتون

عمرو سلامه محمد سلامه ، فؤاد عمر فؤاد ابوزيد

أجريت هذه التجربة خلال مواسم ٢٠١٧ و ٢٠١٨ و ٢٠١٩ على أشجار زيتون "كالاماتا" عمرها تسع سنوات، منزرعة في تربة رملية، على مسافة ٥ × ٥ م، وروت بنظام الري بالتنقيط من بئر. وذلك بهدف دراسة تأثيرالرش الورقى بكلوريد الكالسيوم وحمض الأسكوربيك أولاً: على المحصول، وجودة الثمار، وثانياً: على التزهير فى الموسم التالي، وعقد الثمار لاشجار الزيتون "كالاماتا". تم رش أشجار الزيتون "كالاماتا" بماء الصنبور (مقارنة)، وكلوريد الكالسيوم بتركيزات (١,٠ و ١,٥٪) وحمض الأسكوربيك بتركيزات (١٥٠٠ و ٢٠٠٠ جزء في المليون) بالاضافة معاملة كلوريد الكالسيوم بتركيز (١,٥٪) خلطا مع حمض الأسكوربيك بتركيز (٢٠٠٠ جزء في المليون) وتم اجراء الرش ثلاث مرات فى العام كالاتى: في منتصف شهر مايو(نهاية عقد الثمار)، في منتصف يونيو (أثناء تصلب النواه) وفي الأسبوع الثاني من أكتوبر .أظهرت النتائج أن الرش الورقي لكلوريد الكالسيوم وحمض الأسكوربيك اعطى تأثير إيجابي على محتوى الأوراق من الكلوروفيل والكالسيوم، والمحصول، ومقياس تبادل الحمل، وجودة الثمار وسمك اللب، ومحتوى اللب من الزيت مقارنتا بالاشجارالمقارنة. كما حسنت المعاملات من عملية التزهير التالى مثل عدد النورات/للنمو الخضرى، والعدد الكلي للازهار/النورة، النسبة المئوية لعقد الثمار لزيتون "كالاماتا" مقارنة الأشجار غير المعاملة (المقارنة). وان الرش الورقي لأشجار الزيتون "كالاماتا" بمعاملة كلوريد الكالسيوم بتركيز ١,٥٪ خلطا مع حمض الأسكوربيك بتركيز ٢٠٠٠ جزء في المليون والذى رش ثلاث مرات أثناء مرحلة تطور الثمار كان قادراً على تحسين المحصول، وجودة الثمار، كما أنه حسن من موسم التزهير التالي، وكذلك عقد الثمار.

الكلمات المفتاحية: الكالسيوم، الأسكوربيك، المحصول، الجودة، التزهير.