Effect of Chemical Loosening agents on Harvesting Efficiency and Fruit Quality of Olive Trees

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ABSTRACT

A field experiment was carried out during 2017, 2018 and 2019 seasons on ten year old "Dolce" olive trees grown at private orchard, at Siwa oasis, Marsa Matrouh governorate, Egypt. The aim of this study is evaluating the effect of methionine, ethephon and thiourea as assistant treatments to hand vibration harvest and their effects on leaf (drop and total chlorophyll content) and fruit quality as well as their effect on the next flowering of "Dolce" olive trees. Trees were sprayed, two weeks prior to harvest date with one of the following solutions: (1) control (tap water), (2) methionine at 1000 or 2000 ppm, (3) ethephon at 2000 or 3000 ppm, (4) thiourea at 1000 or 2000 ppm. Control trees recorded the highest fruit detachment force, the highest percentage of hand- picked fruits and the least shed leaves per tree. Ethephon, thiourea and methionine treatments reduced fruit detachment force and supported hand vibration harvest, but increased leaf drop over control trees. All tested treatments gave the highest positive effect on fruit anthocyanin and carotene content as compared with the control. Moreover, perfect flowers and fruit set percentages in the following year responded positively to all treatments, meanwhile, ethephon treatment at 3000 ppm proved to be the most efficient treatments in this concern. Methionine succeeded in enhancing harvesting efficiency percentage and improved fruit color, while it resulted in the lowest effect on fruit removal force, hand- picked fruits percentage and total leaf drop compared to ethephon and thiourea.

Keywords: "Dolce" olive, Methionine, Ethephon, Thiourea, Harvesting efficiency percentage, Next flowering

INTRODUCTION

Olive (*Olea europaea* L.) is one of the important crops in Egypt. It has been regarded as 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). Recently, Dolce olive cultivar cultivated in Siwa oasis is generally used for the olive oil production, although they can also be consumed as olives blacks (pickling). Dolce olive tree has medium to high growth vigor, and it late flowering. It has a medium production. Fruit has average size and it has little regular production. Mainly harvest of Dolce olive tree in Siwa oasis by hand picking.

However, Olive's harvesting is considered one of the biggest problems facing the olive growers. Harvesting process accounts for between 45 and 60% of total production costs of olive (Martin *et al.*, 1994, Metzidakis, 1999 and Özarslan, *et al.*, 2001). Hand harvesting is a slow and expensive method with low harvesting efficiency that needs experienced pickers, as well as the difficulties in collecting all fruits at the optimum harvesting time (Goldental-Cohen *et al.*, 2017).

In Siwa oasis, vegetable intercropping and the special topography of the land, makes mechanical harvest difficult olive groves. In this concern, hand harvesting by vibration would be more efficient by using chemical loosening agents to reduce fruit detachment force. They are cheap easy to apply chemicals, with less leaf drop and no mechanical damages to trees.

In this respect, several chemicals could be used such as ethephon, thiourea and methionine. Ethylene releasing chemicals have been tested as fruit abscission promoters and the best results have been achieved by ethephon and thiourea (Martin *et al.*, 1994). And other ethylene inducing compound such as methionine (Beaudry and Kays, 1988) could be used as fruit abscission promoters.

El-Deeb (2000) and Yousefi *et al.* (2012) mentioned that foliar sprays of ethephon succeeded in reducing fruit detachment force and the percentage of hand-picked olive fruits. Also, Khdair *et al.* (2018) and Abu Zahra (2014) found that ethephon application reduced fruit detachment force. Ethephon had little effect on oil acidity, peroxide value, and oil fatty acid composition of olives (Touss *et al.*, 1995 & Anto`nia and Agust, 2012). Moreover, Zaen El-Daen (2019) indicated that ethephon foliar application increased fruit drop percentage after shaking trees and eased olives harvesting especially at 3500 ppm. Similar results were obtained by Hassan (2002) who sprayed Mission olives with ethephon and thiourea. There is no research on methionine as chemical loosening agents on fruit trees. In this research the first time use methionine as a chemical loosening agents and there are rarely research on this point especially on fruit trees. Valdovinos and Muir (1965)

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mentioned that methionine is very effective in promoting abscission in petioles of cotton and bean. Methionine is a starting material for the formation of plant hormones and growth regulators such as L-Methionine is a precursor of ethylene (Singh, 1999). Methionine is a main ethylene precursor (De Laat *et al.*, 1981 and Dhall, 2013). The role of ethylene was presumed to be abscission. Never the less, spray timing is very important as trees are sprayed in the same time of buds initiation when vegetative buds turn to be reproductive, which would affect flowering and tree crop of the following season. Accordingly, this work aims to evaluate supporting hand vibration harvest by methionine, ethephon and thiourea pre-harvest sprays and to investigate their effects on harvesting efficiency and fruit quality, as well as their influence on the next season flowering of "Dolce" olive trees.

MATERIALS AND METHODS

This study was conducted during two consecutive seasons of 2017, 2018 and 2019 at private orchard, at Siwa oasis, Marsa Matrouh governorate, Egypt. Ten year old "Dolce" olive trees (*Olea europea* L.) healthy, nearly uniform in growth vigor and productivity, growing in a sandy loamy soil, planted at 5x5 m apart, under flood irrigation system and received regularly the same and recommended horticultural practices were devoted for this study. Fourteen days prior to harvest date (November, 15th in both seasons) the selected Dolce olive trees were sprayed with one of the following solutions: ethephon at 2000 or 3000 ppm, methionine at 1000 or 2000 ppm, thiourea at 1000 or 2000 ppm and control (tap water). The experiment was designed as randomized complete block design with four replicates for each treatment and each replicate was represented by one trees. Tween-20 was added at 0.1% as a surfactant to all spray solution including the control "tap water". Spraying was carried out using compression sprayers (6L solution/tree) at the previously mentioned date. A net was installed under each treated tree to collect both fruits and leaves olive that may be abscised before harvest. Preharvest dropped fruits and leaves olive were weighed (fresh weight) separately before hand-vibration harvesting. Olives were harvested at the normal time at ripening stage for the area when about 75% of the olives reached violet color. Response of Dolce olive trees to the chemical loosening agents' treatments were evaluated through measuring the following parameters:

1. Fruit detachment force.

The fruit detachment force (Newton) was measured immediately before hand vibration harvest in a sample of 30 fruit per tree by Beslands-Digital force Gauge apparatus.

2. Harvesting efficiency.

For every treatment, fruit dropped before harvest date, hand vibration dropped fruits (until no more fruits dropped), and harvested fruits by hand picking after hand vibration were collocated and weighed (kg) and the percentage of fruits harvesting efficiency percentage in accordance to the harvest method: Pre-harvest dropped fruits, hand vibration harvested fruits and hand picked fruits was calculated according to the following equation:

Harvesting efficiency (%) = fruit weight obtained by a certain harvest method / total harvested fruit weight ×100

3. Leaf abscission.

The dropped leaves at pre-harvest, abscised leaves by hand vibration harvest and leaves dropped during hand picking were collocated and weighed (kg) and the percentage of abscised leaves by hand vibration harvest and hand picking harvest were calculated on the basis of total abscised leaves.

4. Leaf chlorophyll content

After 15 days of chemical loosening agents foliar spray, leaf total chlorophyll content was determined by Minolta chlorophyll meter SPAD-502.

5. Flowering and fruiting parameters:

The effect of chemical loosening agents and leaf drop 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, number of flowers/ panicles and number of perfect flowers/ panicles and the percentage of perfect flowers equaled (number of perfect flowers/total number of flowers x100). Moreover, the percentage of initial fruit set (three weeks after full bloom) equaled (initial number of fruit setting /total number of flowers at full bloom) x100).

6. Fruit properties:

To evaluate the effects of the tested chemicals on fruit quality, a random sample of fifty fruits per tree was taken: fruit dimensions (length and width) and fruit firmness was measured by a pressure tester the average firmness of fruits was measured in kg/cm^2 by Magness and Ballaut pressure tester equipped with 5/16 inch plunger.

Also, fruit anthocyanin content in the peel was assessed according to the method of Fuleki and Francis (1968) and fruit peel beta-carotene content was determined according to (Lichtenthaler and Wellburn, 1985). In addition, fruit oil content as dry weight was

determined by means of soxhalt extraction apparatus using petroleum ether as described by AOAC (1995).

8. Statistical analysis

The obtained data in both seasons were subjected to analysis of variance according to Clarke and Kempson (1997) and means were differentiated using Rang test at the 0.05 level (Duncan, 1955).

RESULTS AND DISCUSSION

1. Fruit detachment force.

Table (1) demonstrates that fruit detachment force of all tested treatments ranged from 1.88 to 4.80 N in the first season and from 1.69 to 4.38 N in the second one. Methionine, ethephon and thiourea treatments succeeded in reducing fruit detachment force values as compared with control treatment in both seasons. The most effective treatments were 3000 ppm ethephon, 2000 ppm ethephon, 2000 ppm thiourea, 1000 ppm thiourea and 2000 ppm methionine, respectively. Whereas, 1000 ppm methionine treatment revalues lower effect in both seasons. The highest value of fruit detachment force was 4.80 & 4.38 N in the two seasons for control treatment. Methionine at 2000 ppm recorded a force value of 2.38 & 2.44 N both seasons. Meanwhile, 1000 ppm methionine recorded 2.52 & 2.62 N in both seasons compared to 3000 ppm ethephon that recorded 1.57 & 1.69 N in both seasons. Obtained resulted go in line with the finding of El-Deeb (2000) and Yousefi *et al.* (2012) who worked on olive, and mentioned that ethephon foliar sprays succeeded in reducing fruit detachment force and the percentage of hand-picked olive fruits. These findings were similarly confirmed by Abu Zahra (2014) and Khdair *et al.* (2018) working on olives. In addition, Hassan (2002) showed that ethephon and thiourea foliar spraying reduced fruit detachment force of "Mission" olives. Furthermore, Valdovinos and Muir (1965) reported that methionine enhanced abscission in petioles of cotton and bean

The enhancement effect of ethephon, thiourea and methionine in reducing fruit removal force may be attributed that ethephon and thiourea are ethylene releasing (Martin *et al.,* 1994) as well as methionine is the precursor of ethylene (Beaudry & Kays, 1988; Singh, 1999 and Dhall, 2013). The role of ethylene was to be promoting abscission in petioles fruits. It is concluded that ethylene leads to increase activities of ethylene biosynthesis enzymes in the abscission zone. This may explain ethephon, thiourea and methionine potency in enhancing fruit harvesting due to occurring abscission zone (Hegazi *et al.,* 1987*).*

Table 1. Effect of methionine, ethephon and thiourea loosening agents on fruit detachment force of Dolce olive (2017 and 2018 seasons).

Treatments	Fruit detachment force (Newton)	
	2017	2018
Water only (control)	4.80 a	4.38 a
1000 ppm Methionine	2.52 b	2.62 b
2000 ppm Methionine	2.38 c	2.44 cd
2000 ppm Ethephon	1.88 e	2.97 e
3000 ppm Ethephon	1.57 f	1.69 f
1000 ppm Thiourea	2.28 cd	2.31 cd
2000 ppm Thiourea	2.21 d	2.24 d

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

2. Harvesting efficiency (%):

2.1 Pre-harvest fruits drop.

Table (2) shows that all tested chemical loosening agents recorded higher percentage of harvesting efficiency at the stage of pre-harvest drop than water spraying (control). The percentage of pre-harvest dropped fruits ranged from 3.48 to 26.10 in the first season and from 4.17 to 20.17 % in the second one. Ethephon at (3000 and 2000 ppm) and thiourea at (2000 and 1000 ppm) gave the similar positive effect on harvesting efficiency at the pre-harvest fruit drop in the first season. The 3000 ppm ethephon treatment proved to be the superior treatment in the second season. Thiourea sprayed at both concentrations gave an intermediate value compared to the other two chemical loosening agents.

2.2. Hand vibrating harvest fruit percentage.

It is clear from table (2) that all tested chemical loosening agents sprayed trees record higher percentage of harvesting efficiency at hand vibration harvest fruits as compared with control in the both seasons. Hand vibration fruits harvest ranged from 12.67 to 64.85 % in the first season and from 9.47 to 68.66 % in the second one. Ethephon at two concentrations in the first season and ethephon at 3000 ppm treatments in the second season proved to be the superior treatment in this respect. Control gave the lowest values in this concern. Thiourea treatments gave an intermediate values other two methionine and ethephon loosening agents in this respect.

2.3. Total harvesting efficiency during Pre-harvest and hand vibration harvest.

Table (2) show that all tested methionine, ethephon and thiourea sprayed trees produced higher total harvesting efficiency percentage during (pre-harvest drop fruits and hand vibration harvest fruits) than those sprayed trees with tap water "control". Percentage of

total harvesting efficiency generally ranged from 16.15 to 90.94 % in the first season and from 13.64 to 88.0 % in the second ones.

Ethephon at two concentrations in the first season and ethephon at 3000 ppm in the second season proved to be the best treatments in this respect.

Methionine at two concentrations gave intermediate values of total harvesting efficiency as compared with ethephon and thiourea treatments in this respect. Control (tap water) gave the lowest total harvesting efficiency percentage during (pre-harvest drop fruits and hand vibration harvest fruits) in this respect.

2.4. Hand-picked fruits percentage.

Table (2) show that hand-picked fruits generally ranged from 9.06 to 83.86% in the first season and from 11.17 to 86.36% in the second season.

The percentage of olive remaining on the trees of hand-picked vibration harvest decreased significantly with the ethephon, thiourea and methionine treatments. The highest percentage 83.86 & 86.36% in the two seasons were recorded by untreated trees, followed by 1000 ppm methionine treatment 32.35 & 42.03% respectively. On the contrary, lower percentage of hand-picked fruits values 9.06 & 11.17% were recorded by 3000 ppm ethephon treatment in both season. Thiourea at two concentrations gave an intermediate values between ethephon and methionine in this concern.

The obtained results of ethephon, thiourea and methionine regarding their positive effect on harvesting efficiency are in harmony with the findings of Hegazi *et al.* (1987) on two olive cultivars; El-Deeb (2000) and Yousefi *et al.* (2012) on olive. Moreover, Zaen El-Daen (2019) mentioned that ethephon foliar sprays enhanced harvesting efficiency percentage of olive trees especially at 3500 ppm. Furthermore, Hassan (2002) reported that thiourea foliar spray increased harvesting efficiency percentage of Mission olives. Additionally, Methionine is a precursor of ethylene (De Laat *et al.*, 1981 and Dhall, 2013). The role of ethylene was presumed to be abscission whereas, ethylene induced reduction in fruit detachment force and so that it was reflected in improved pre-harvest and hand vibration harvest.

In this concern, Valdovinos and Muir (1965) reported that methionine improved abscission in petioles of cotton and bean. The enhancement effect of ethephon, thiourea and methionine on harvesting efficiency may be attributed that all ethephon, thiourea and methionine lead to induce ethylene. And ethylene induced reduction in fruit detachment force and so that it was reflected in improved Pre-harvest and hand vibration harvest.

Table 2. Effect of methionine, ethephon and thiourea loosening agents on of Dolce olive (2017 and 2018 seasons).

Treatments	Harvesting efficiency (%)			
	Pre-harvest dropped fruits (%)		Hand vibration harvested fruits (%)	
	2017	2018	2017	2018
Water only (control)	3.48 c	4.17 e	12.67 e	9.47 f
1000 ppm Methionine	20.82 b	8.15 d	46.83 c	49.82 e
2000 ppm Methionine	23.29 ab	9.46 cd	48.70 bc	52.34 de
2000 ppm Ethephon	25.64 a	14.64 b	62.67 a	66.04 ab
3000 ppm Ethephon	26.09 a	20.17 a	64.85 a	68.66 a
1000 ppm Thiourea	24.23 a	11.64 bc	53.40 bc	56.24 cd
2000 ppm Thiourea	26.10 a	12.47 bc	55.43 b	60.56 bc
	Pre-harvested + Hand vibration harvested fruits (%)		Hand-picked fruits (%)	
	2017	2018	2017	2018
Water only (control)	16.15 d	13.64 f	83.86 a	86.36 a
1000 ppm Methionine	67.65 c	57.97 e	32.35 b	42.03 b
2000 ppm Methionine	71.99 bc	61.80 de	28.01 bc	38.20 bc
2000 ppm Ethephon	88.31 a	80.68 b	11.70 d	19.32 e
3000 ppm Ethephon	90.94 a	88.83 a	9.06 d	11.17 f
1000 ppm Thiourea	77.63 b	67.88 cd	22.37 c	32.12 cd
2000 ppm Thiourea	81.52 ab	73.03 bc	18.48 cd	26.97 de

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

3. Leaf drop:

3.1. Leaf drop (kg/tree):

Table (3) shows that all tested treatments caused significant increment in leaf drop (kg/tree) as compared with the control. Moreover, two concentrations of ethephon treatments recorded the highest values of leaf drop descending followed by both concentrations of thiourea and methionine treatments, respectively. Generally, 3000 ppm ethephon treatment recorded the highest values in both seasons. Besides, 1000 and 2000 ppm methionine treatments scared low values than did 1000 and 2000 ppm thiourea treatments. However, thiourea treatments gave an intermediate values in this concern.

3.2. Pre-harvest leaf drop (%):

Table (3) demonstrates that all tested treatments caused significant increments in percentage of per-harvest leaf drop as compared with the control. Furthermore, ethephon recorded the highest values descending followed by thiourea and methionine treatments, respectively. Moreover, 3000 ppm ethephon recorded the highest values compared the control (tap water) which recorded the lowest values in both seasons.

3.3. Leaf drop during hand vibration harvest (%):

Table (3) illustrates that all tested treatments increased the percentage of leaf drop during hand vibration as compared with the control. Ethephon treatments gave higher positive effect on leaf drop during hand vibration than thiourea and methionine treatments in both seasons. Generally, ethephon at 2000 and 3000 ppm scored statistically similar and high values in both seasons. Methionine at 2000 and 1000 ppm treatments gave the lower values than thiourea at 2000 and 1000 ppm treatments and the lowest values recorded by the control (tap water).

3.4. Total leaf drop during preharvest and hand vibration harvest (%):

Table (3) mentions that all tested treatments ranged from 25.40 to 88.14% in the first season and from 24.78 to 92.83% in the second one.

Ethephon sprayed trees gave higher percentage of their total leaves during preharvest and hand vibration harvest as compared with control treatment in both seasons. The higher values recorded by 3000 ppm ethephon (88.14 and 92.83% in the two seasons), while the control treatment recorded lower values (25.40 and 24.78%) in two seasons.

Table 3. Effect of methionine, ethephon and thiourea loosening agents on total weight of dropped leaves percentages of pre-harvest leaf drop, leaf drop during hand vibration harvesting and total leaf drop of Dolce olive (2017 and 2018 seasons).

Treatments	Total weight of dropped leaves (Kg/tree)		Pre-harvest leaf drop (%)	
	2017	2018	2017	2018
Water only (control)	0.303 g	0.216 f	9.86 e	8.74 d
1000 ppm Methionine	0.776 f	1.080 e	11.63 de	13.06 c
2000 ppm Methionine	0.950 e	1.220 d	13.50 cd	14.51 bc
2000 ppm Ethephon	2.916 b	3.130 a	17.48 b	16.19 b
3000 ppm Ethephon	3.233 a	3.250 a	22.07 a	20.42 a
1000 ppm Thiourea	2.616 d	2.716 c	14.89 bc	15.46 bc
2000 ppm Thiourea	2.740 c	2.896 b	16.28 bc	18.75 a
	Leaf drop during hand Vibration harvesting (%)		Total leaf drop (%)	
	2017	2018	2017	2018
Water only (control)	15.54 e	16.05 c	25.40 e	24.78 e
1000 ppm Methionine	26.99 d	37.13 b	38.62 d	50.19 d
2000 ppm Methionine	35.87 cd	39.41 b	49.37 cd	53.92 d
2000 ppm Ethephon	61.78 a	63.88 a	79.26 a	80.06 b
3000 ppm Ethephon	66.08 a	72.41 a	88.14 a	92.83 a
1000 ppm Thiourea	40.20 c	41.83 b	55.09 c	57.29 cd
2000 ppm Thiourea	51.37 b	45.48 b	67.65 b	64.23 c

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

Both methionine concentrations gave lower percentage of total leaves during pre- harvest and hand vibration harvest than ethephon and thiourea treatments.

The thiourea treatments gave an intermediate values between ethephon and methionine sprayed in this concern.

3.5. Leaf drop during hand picking (%):

Table (4) indicates that all treatments ranged from 74.60 to 11.85% in the first season and 75.22 to 8.61% in the second season. Tap water sprayed trees "control" lost higher percentage of their leaves during hand picking as compared with those sprayed with other tested treatments in both seasons. The highest values were recorded by the control (74.60 and 75.22% in the two seasons), while the other treatments recorded much lower leaves drop values (from 61.29 to 11.85% in the first season and from 48.07 and to 8.61% in the second one). Moreover, 1000 ppm methionine sprayed trees recorded high values of their leaves drop during hand picking (61.29 and 48.07% in the two seasons), while 2000 ppm methionine sprayed trees recorded (50.63 and 47.54% in two seasons). However, 3000 ppm ethephon sprayed trees lost less percentage of their leaves during hand picking recorded (11.85 and 8.61% in two seasons).

4. Leaf total chlorophyll content.

It clears from Table (4) that 3000 ppm ethephon treatment exerted a significant reduction in leaf chlorophyll content as compared with control in both seasons. Other treatments had no significant effect on total chlorophyll including control treatment.

The obtained results regarding the effect of ethephon, thiourea and methionine on Leaf drop go in line with the findings El-Deeb (2000); Yousefi *et al.* (2012) and Zaen El-Daen (2019) on olive trees. They mentioned that ethephon foliar sprays reduced fruit detachment force but increased leaf drop over control trees. Furthermore, Hassan (2002) stated that thiourea foliar spray increased harvesting efficiency percentage but leaf drop increased as compared with control of Mission olives. However, methionine is a precursor of ethylene (De Laat *et al.,* 1981 and Dhall, 2013). Ethylene has physiological effects of chemical defoliants (Suttle, 1984). Ethylene induced reduction in fruit detachment force and increased leaf drop over control treatment (Valdovinos and Muir, 1965) on cotton and bean. In addition, the effect of ethephon on leaf chlorophyll content is in harmony with the finding of Royer *et al.* (2006) and Tsantili and Pontikis (2004). They mentioned that ethephon can accelerate chlorophyll degradation of olive leaves. However, our results of thiourea and methionine had no significant effect on total chlorophyll including control treatment. On the contrary, many studied mentioned that thiourea enhanced chlorophyll content. Meanwhile, foliar spray of methionine increased total chlorophyll contents of okra **(**Zulqadar *et al.,* 2015) and Attia (2018) on grapes. It could be refer to that thiourea and methionine could need more time to induce effect on leaf chlorophyll content and/or it thiourea and methionine degradation by plant after spraying direct and /or other factors make plant not ready to response to give effect on leaf chlorophyll content.

5. Flowering characteristics:

5.1. Number of panicles per shoots

It is clear from Table (5) that all treatments failed to induce any positive effect on number of panicles per shoot in both seasons.

5.2. Number of flowers/ panicles

It quite evidence from Table (5) that all chemical loosening agents failed to exerted a pronounced effect on number of flowers per shoot in both seasons.

Table 4. Effect of methionine, ethephon and thiourea loosening agents on leaf drop during hand-picked fruits and leaf chlorophyll content of Dolce olive (2017 and 2018 seasons).

Treatments	Leaf drop during hand-picked fruits (%)		Total chlorophyll	
	2017	2018	2017	2018
Water only (control)	74.60 a	75.22 a	74.0 a	73.6 a
1000 ppm Methionine	61.29 b	48.07 b	74.0 a	74.0 a
2000 ppm Methionine	50.63 bc	47.54 b	75.0 a	74.3 a
2000 ppm Ethephon	20.74 e	22.59 d	66.0 b	69.0 b
3000 ppm Ethephon	11.85 e	8.61 e	62.0 c	67.0 b
1000 ppm Thiourea	44.91 c	41.03 bc	75.0 a	75.0 a
2000 ppm Thiourea	32.35 d	36.69 c	76.0 a	75.6 a

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

5.3. Perfect flowers percentage

It is clear from Table (6), that all tested treatments succeeded in increasing perfect flowers percentage of "Dolce" olive trees as compared with the control treatment in both seasons of study. However, 2000 and 3000 ppm ethephon treatments show superiority in this respect. Other treatments gave an intermediate values in this respect.

5.4. Fruit set percentage.

It is observed from Table (6) in both seasons, ethephon sprayed trees exerted higher fruit set percentage followed by descendent by thiourea and methionine as compared with control. Methionine gave the lowest values as compared with ethephon and thiourea in this respect.

The obtained results of ethephon, thiourea and methionine on flowering are in harmony with the findings of Hassan (2002) who mentioned that ethephon and thiourea had no effect on number of flowers/shoots but had a positive effect on fruit set percentage of "Mission" olive trees.

El-Deeb (2000) reported that foliar sprays of ethephon induced a positive effect of fruit set percentage "Picual" olive fruits.

In addition, foliar spray of methionine increased the number of flowers and number of fruits of okra **(**Zulqadar *et al.,* 2015) and Attia (2018) on grapes.

The enhancement effect of ethephon, thiourea and methionine on flowering characteristics may be attributed to this chemicals agents finally induced ethylene. And ethylene led to this positive effect on flowering.

This supported by Papadopoulou *et al.* (2005) mentioned that ethylene appears to be a key hormone regulating the sex determination process. It increased femaleness and increased number of bisexual buds in melon plants. So that, ethylene is important not only for sex determination, but also for development of the bisexual (hermaphrodite) bud to maturity. And confirmed on cucumber (Owens *et al.,* 1980 and Yamasaki *et al.,* 2001).

Also, methionine plays an important role in ethylene biosynthesis. The biosynthesis of ethylene includes three steps, the first leading from methionine to S-Adenosyl-Methionine (SAM) catalyzed by the S-adenosyl-methionine synthetase (SAM synthetase), the second transforming SAM into 1-aminocyclopropane-1-carboxylic acid (ACC) by ACC synthase (ACS) and finally the production of ethylene from ACC by ACC oxidase (ACO).

Table 5. Effect of methionine, ethephon and thiourea loosening agents on number of panicles per shoot and number of flowers per panicles of "Dolce" olive (2018 and 2019 seasons).

Treatments	number of panicles per shoot		number of flowers per panicles	
	2018	2019	2018	2019
Water only (control)	9.39 a	5.61 a	13.58 a	13.12 a
1000 ppm Methionine	9.38 a	5.60 a	13.57 a	13.11 a
2000 ppm Methionine	9.42 a	5.64 a	13.64 a	13.18 a
2000 ppm Ethephon	9.39 a	5.61 a	13.61 a	13.15 a
3000 ppm Ethephon	9.40 a	5.62 a	13.61 a	13.15 a
1000 ppm Thiourea	9.40 a	5.62 a	13.61 a	13.15 a
2000 ppm Thiourea	9.40 a	5.62 a	13.61 a	13.18 a

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

Table 6. Effect of methionine, ethephon and thiourea loosening agents on perfect flowers percentage and fruit set percentage of "Dolce" olive (2018 and 2019 seasons).

Treatments	Perfect flowers (%)		Fruit set (%)	
	2018	2019	2018	2019
Water only (control)	9.00 c	8.00 c	31.67 B	31.0 D
1000 ppm Methionine	10.30 b	9.32 b	32.64 AB	32.0 CD
2000 ppm Methionine	10.33 b	9.33 b	33.66 AB	33.0 BCD
2000 ppm Ethephon	11.32 a	10.58 a	35.61 A	36.0 AB
3000 ppm Ethephon	11.60 a	10.60 a	35.66 A	37.0 A
1000 ppm Thiourea	10.32 b	9.33 b	35.45 AB	34.0 ABCD
2000 ppm Thiourea	10.34 b	9.35 b	35.62 AB	35.0 ABC

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

The pool of ACC is also regulated by conjugation via ACC acyl-transferases leading to the formation of ACC derivatives like malonyl-ACC, glutamyl-ACC, and jasmonyl-ACC, which affects the pools of free ACC and hence ethylene biosynthesis (Fluhr *et al.*, 1996; Johnson & Ecker 1998; Zarembinski and Theologis 1994).

6. Fruit physical properties

6.1. Fruit length (cm)

It is clear from Table (7), that all tested treatments failed to induced any significant effect on fruit length in both seasons.

6.2. Fruit width (cm)

It quite evidence from Table (7) that all chemical loosening agents failed to exerted a pronounced effect on fruit width in both seasons.

6.3. Fruit firmness (kg/cm)^2

Table (7) demonstrates that all tested treatments failed to induce any positive effect on number on fruit firmness as compared with control in both seasons.

6.4. Anthocyanin content (mg/100)

Tabulated data demonstrate that ethephon, thiourea and methionine amino acid treatments induced a pronounced high positive effect on fruit anthocyanin content as compared with the control in both seasons. Briefly, 3000 ppm ethephon treatment proved to be the most efficient treatment in increasing fruit anthocyanin content in both seasons. Other tested treatments showed an intermediate values from the statistical standpoint (Table 8).

6.5. Carotene (mg/100)

Statistical analysis indicated that ethephon, thiourea and methionine amino acid treatments scored significantly higher values of fruit carotene content as compared with the control treatment in both seasons of study. Generally, ethephon treatment surpassed thiourea and methionine amino acid treatments in enhancing fruit carotene content. Moreover, 3000 ppm ethephon treatment proved to be the most efficient treatment in scoring the highest values in both seasons, respectively (Table 8).

The obtain results of ethephon, thiourea and methionine on olive fruits properties go in line with the findings of Hassan (2002) on fruit olive. He reported that ethephon and thiourea had no significant effect on fruit length and width of "Mission" olive fruits. Moreover, Brighenti *et al.* (2017) mentioned that ethephon had positive effect on anthocyanin contents of fruit apple and Attia (2018) on berry "Flame Seedless" Table Grapes.

Table 7. Effect of methionine, ethephon and thiourea loosening agents on fruit (length and width) and fruit firmness of "Dolce" olive (2017 and 2018 seasons).

Treatments	Fruit length (cm)		Fruit width (cm)		Fruit firmness (kg/cm^2)	
	2017	2018	2017	2018	2017	2018
Water only (control)	2.85 a	3.02 a	1.75 a	1.81 a	4.767 a	5.470 a
1000 ppm Methionine	2.84 a	3.01 a	1.76 a	1.82 a	4.763 a	5.470 a
2000 ppm Methionine	2.85 a	2.01 a	1.75 a	1.82 a	4.761 a	5.470 a
2000 ppm Ethephon	2.85 a	3.03 a	1.77 a	1.83 a	4.756 a	5.464 a
3000 ppm Ethephon	2.86 a	3.03 a	1.77 a	1.83 a	4.754 a	5.460 a
1000 ppm Thiourea	2.86 a	3.03 a	1.78 a	1.85 a	4.760 a	5.464 a
2000 ppm Thiourea	2.88 a	3.05 a	1.79 a	1.85 a	4.760 a	5.463 a

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

Table 8. Effect of methionine, ethephon and thiourea loosening agents on fruit anthocyanin, carotene and oil content of Dolce olive (2017 and 2018 seasons).

Treatments	Anthocyanin content (mg/100)		Carotene (mg/100)		Oil content (%)	
	2017	2018	2017	2018	2017	2018
Water only (control)	14.30 f	15.13 f	0.388 g	0.413 g	16.78 a	16.51 a
1000 ppm Methionine	17.90 e	18.36 e	0.422 f	0.429 f	16.76 a	16.50 a
2000 ppm Methionine	18.53de	20.10 cd	0.463 c	0.438 e	16.73 a	16.52 a
2000 ppm Ethephon	24.27 b	23.77 b	0.659 b	0.672 b	16.76 a	16.50 a
3000 ppm Ethephon	26.86 a	25.40 a	0.689 a	0.683 a	16.78 a	16.50 a
1000 ppm Thiourea	19.53 d	19.83 d	0.431 e	0.444 d	16.71 a	16.48 a
2000 ppm Thiourea	21.13 c	21.16 c	0.448 d	0.454 c	16.73 a	16.49 a

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

Furthermore, the increment effect of thiourea in carotenoid contents corroborated with the findings of Zahra *et al.* (2018). Moreover, the improvement effect of thiourea in anthocyanin and carotenoids content is in consonance with the findings of El-Awadi *et al.* (2011) on snap bean; Bakry *et al.* (2018) on flax plants and Attia (2018) on grapes. Foliar ethephon, thiourea and methionine enhanced the endogenous ethylene concentration moreover, promote or inhibit growth and senescence processes depending on its concentration, as well as it stimulating the synthesis of anthocyanins (Li *et al.*, 2017).

That refer to that ethylene, is regulates many processes of plant growth and development, including root hair formation, flowering, the senescence and abscission of fruit and leaf as well as coloration (Dugardeyn and Van Der Straeten, 2008).

7. Oil content percentage

It clears from Table (8) that oil content showed statistically similar response to all tested treatment including control. Similar results were obtained by Hassan (2002) on fruit "Mission" olive.

On the contrary, other studied reported that ethephon treatment had a positive effect on oil content of Koroneiki and Coratina olive cultivars grown in Siwa Oasis (Zaen El-Daen, 2019).

CONCLUSION

The present study showed that the chemical loosening agents succeeded in reducing fruit removal force and increased the percentage of pre-harvest dropped fruits and fruits harvested by hand vibration. The different treatments also enhanced fruit anthocyanin and carotene content, increased perfect flowers and fruit set percentages of the following season. Thus such chemicals might be recommended to be used to facilitate harvesting in olive groves grown under similar conditions of the present study.

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الملخص العربي

تاثير مواد الفصل الكيميائية على كفاءة الحصاد وجودة ثمار أشجار الزيتون

عمرو سلامه محمد سلامه

اجريت تجربة حقلية خلال مواسم ٢٠١٧، ٢٠١٨، ٢٠١٩ م على أشجار زيتون دولسى عمر ١٠ سنوات والنامية فى مزرعة خاصة فى واحة سيوة، محافظة مرسى مطروح، مصر. هدف الدراسة تقييم تاثير المثيونين والاثيفون والثيوريا كمعاملات فصل مساعدة على الجمع اليدوى للثمار بطريقة هز الأشجار، والتاثيرات المصاحبة لها على تزهير العام التالى لاشجار زيتون دولسى. رشت الأشجار قبل موعد الجمع باسبوعين بأحد المحاليل الاتية:

١-ماء الصنبور (مقارنة)

٢-الحمض الامينى المثيونين بتركيز ١٠٠٠، ٢٠٠٠ جزء فى المليون

٣-الاثيفون بتركيز ٢٠٠٠، ٣٠٠٠ جزء فى المليون

٤-الثيوريا بتركيز ١٠٠٠، ٢٠٠٠ جزء فى المليون

اظهرت النتائج أن أشجار المقارنة سجلت أكبر قوة لفصل الثمرة من الافرع وأكبر نسبة مئوية من المحصول بالقطف اليدوى وأقل وزن للاوراق المتساقطة خلال القطف اليدوى.

وان معاملات الاثيفون والثيوريا والمثيونين قللت من قوة فصل الثمار، ودعمت من الحصاد اليدوى بالهز، ولكن زادت من تساقط الأوراق عن أشجار المقارنة.

وأن كل المعاملات المختبرة اعطت تاثيرات إيجابية على محتوى الثمار من الانثيوسيانين والكاروتين بالمقارنة بالاشجار التى رشت بماء الصنبور (المقارنة).

واستجابت النسبة المئوية للازهار الكاملة والنسبة المئوية للعقد بشكل إيجابى لكل المعاملات، بينما كان الاثيفون بتركيز ٣٠٠٠ جزء فى المليون افضل المعاملات فى هذا الصدد.

ونجح المثيونين فى تحسين النسبة المئوية لكفاءة الحصاد، وتحسين لون الثمار لاشجار الزيتون الدولسى. ولكن اعطى المثيونين على مستوى التركيزين أقل تاثير إيجابى على القوة اللازمة لفصل الثمار، والنسبة المئوية لقطف الثمار باليد، والأوراق المتساقطة الكلية.

الكلمات المفتاحية: زيتون دولسى، المثيونين، الاثيفون، الثيوريا، نسبة كفاءة الجمع، الازهار التالى.