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Effect of spraying ethephon on fruits harvest of olive trees under Siwa oasis conditions

Zaen El-Daen E.M.A.

Plant Production Department, Desert Research Center, Cairo, Egypt.

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ABSTRACT

This study was carried out through two successive seasons 2015 &2016 to determine the optimum ethephon concentration on fruit harvesting of Koroneiki and coratina olive cultivars grown in a private farm in Tnkmamo region located at Siwa oasis, Matrouh governorate, Egypt. Four treatments were consisted of control and three ethephon concentrations 1500, 2500 and 3500 ppm. Data were collected after eight days from ethephon spraying. Results indicated that ethephon foliar application by all studied concentrations makes olive fruits harvesting easy especially at 3500 ppm where increased dropped fruits percentage after shaking trees. Besides, reduced remaining fruits percentage after shaking and oil acidity percentage. This concentration enhanced fruits ripening where increased black fruits percentage but led to a somewhat increase in dropped leaves percentage before or after shaking trees. There is no significant difference between all ethephon concentrations in fruits moister percentage. The lowest numbers of vegetative and flowering opened buds in the next season after treatments recorded with 3500 ppm ethephon but this decrease less than affecting in growth and flowering of koroneiki olive trees and may be effect on growth and flowering of coratina cultivar.

***Keywords*:** Ethephon, Koroneiki, coratina, olive fruits harvesting, fruits ripening, vegetative and flowering opened buds.

Introduction

Olive cultivation accounts for 59% of the total cultivated area in Siwa Oasis, which is the main income of most of the oasis population. About 54.4% of the area planted with olives in Siwa is concentrated in both Siwa city and Abusharof village together. Studies show that there is an increase in the cost of personnel, accounting for 41.3% of the total production costs. Manual collection of fruits costs the highest proportion which considered costly and exceeds 60% of the entire production cost (Zimbalatti, 2004 & Ferguson, 2006). The Koroneiki cultivar is a small fruits of the weights from 0.7 to 1 g, its oil percentage in fruits was between 20 to 23% (Anonymous 2000).

The efficiency of the mechanical collection of olive fruits depends on the strength of the fruit in branches and tree stems. The fruits have stronger and great resistance when shaking trees, which leads to the survival of a percentage of fruits, stuck to trees after harvesting. This is due to the uneven maturity of the fruits on the trees where there are immature fruits on the trees which are firmly held in the branches and other fruits over ripening which dropped on the ground. This makes a problem when we use a machine in harvesting. To solve this problem we should make a balance in fruits ripening and reducing the resistance of the fruit stalks on vibrating for mechanized harvesting we can use foliar application by chemical substances before harvesting (Martin, 1994; Whitney *et al.,* 2000).

Many of authors reported that ethephon is a synthetic plant growth regulator. It makes mechanical olive fruits harvesting easy and can accelerate chlorophyll degradation and enhance the ripening of in olive fruits (Royer *et al.,* 2006 &Tsantili and Pontikis, 2004). Yousefi *et al.,* (2010) and Sessiz *et al*. (2006) they found that the harvesting productivity percentage of the olive fruits increased by using of Ethrel by 3.125 and 6.25 ml/lit by 46 % and 103 %, respectively and decreased the fruit-removal-force (FRF). Besides, spraying Ethrel at 2000 ppm before shaking olive trees makes harvesting easy as the findings by Ozguven *et al*. (2007). Ethephon foliar application near to time of harvest decrease (FRF). With decreasing of this force, harvesting productivity increases and olives harvesting machines required less power to harvesting but leaf loss higher than without spraying ethephon. These obtained results of fruit harvesting were with ethephon at3000 ppm. Also, positive correlations were found between the total leaf drop percent and the total harvested fruits (Yousefi *et al*. 2012, Adnan *et al.* 2018 and Taleb Abu Zahra, 2014). Using ethephon at 1250 and 1875 mg·liter–1

Corresponding Author: Zaen El-Daen E.M.A., Plant Production Department, Desert Research Center, Cairo, Egypt. E-mail: zaeneldeeneid@yahoo.com

on conventional 'Arbequina' olive trees increased the yield from mechanical harvesting by 20% and did not adversely affect flowering the following year. Ethephon had little effect on oil acidity, peroxide value, and oil fatty acid composition (Touss 1995 & Antonia and Agust 2012).

The main target of this research investigates the role of using Ethephon spraying in solve olive fruits harvesting problem and its effect on some oil olive properties under Siwa Oasis conditions.

Materials and Methods

This study was carried out on Koroneiki and coratina olive cultivars grown in a private farm in Tnkmamo region located at Siwa Oasis, Matrouh Governorate, Egypt. 24 olive trees of about 10 years old from every cultivar were selected randomly in the same field. Trees were fertilized and irrigated by recommended doses. Every cultivar was an individual experiment. Four treatments, (T1) foliar application by distilled water (control), foliar application by three Ethephon concentrations. (T2) 1500 ppm, (T3) 2500 ppm and (T4) 3500 ppm were used at three replicates and every replicate contains two trees. Form each tree three branches were selected and covered with net bags to collect the dropped leaves and fruits. Eight days after Ethephon applications, the dropped leaves and fruits on every net bag were collected before and after shaking. After removing net bags we collect remaining fruits from each branch manually.

Measured Parameters:

From collecting fruits and leaves on each covered branches the following data were calculated as percentage according to their equations.

Total dropped leaves:

Dropped leaves before and after shaking were counted to calculate dropped leaves percentage before and after shaking as following equations:

$$\%\ Dropped\ leaves\ before\ shaking = \frac{Number\ of\ dropped\ leaves\ before\ shaking}{Total\ number\ of\ leaves\ per\ branch} \times 100$$

$$\%\ Dropped\ leaves\ after\ shaking = \frac{Number\ of\ dropped\ leaves\ after\ shaking}{Total\ number\ of\ leaves\ per\ branch} \times 100$$

Total dropped fruits:

Dropped fruits before shaking were weighted to calculate dropped fruits percentage before shaking as following equation:

$$\%\ Dropped\ fruits\ before\ shaking = \frac{Weight\ of\ dropped\ fruits\ before\ shaking}{Total\ weight\ of\ fruits\ per\ branch} \times 100$$

$$\%\ Remaining\ fruits\ weight\ before\ shaking = Total\ fruit\ weight\ per\ branch - Weight\ of\ dropped\ fruits\ before\ shaking$$

$$\%\ Remaining\ fruits\ weight\ before\ shaking = \frac{Remaining\ fruits\ weight\ before\ shaking}{Total\ weight\ of\ fruits\ per\ branch} \times 100$$

Total harvested fruits:

All dropped fruits before and after shaking were weighted and the remaining fruits from each branch were collecting manually and weighted to calculate harvested fruits percentage and remaining fruits percentage after shaking as following equations:

$$\%\ Harvested\ fruits = \frac{Total\ weight\ of\ dropped\ fruits\ before\ and\ after\ shaking}{Total\ fruit\ weight\ per\ branch} \times 100$$

$$\%\ Remaining\ fruits = \frac{Total\ weight\ of\ remaining\ fruits\ after\ shaking}{Total\ fruit\ weight\ per\ branch} \times 100$$

Ripening degrees:

All harvested fruits were divided to green fruits and black fruits, and then each group was weighted to calculate green fruits and black fruits percentage according to the following equations:

$$\% \text{ Green harvested fruits} = \frac{\text{Total weight of green harvested fruits}}{\text{Total weight of harvested fruit}} \times 100$$

$$\% \text{ Black harvested fruits} = \frac{\text{Total weight of black harvested fruits}}{\text{Total weight of harvested fruit}} \times 100$$

To study the effect of ethephon on vegetative and flowering buds the number of each vegetative or flowering buds per branch in the follow year after treatment were counted and recorded.

Chemical Characteristics:

Moisture Content: It was determined by drying the flesh in an oven at 60-80°C until a constant weight according to A.O.A.C. (1975)

Acid Percentage: It was determined according to the A.O.C.S. method (1964).

Experimental design:

A randomized completely blocks design (RCBD), with four treatments and three replicates (two trees per each replicate) were used.

Statistical analysis:

The obtained data of both seasons were subjected to analysis of variance according to Snedecor and Cochran, (1989) and the means were differentiated using Duncan multiple range test at 5% level. Duncan (1955).

Results and Discussion

Data obtained from koroneki and coratina olive cultivars treated with ethephon foliar application to study its effect on fruits harvesting efficiency and others effects as leaves and fruits dropping, fruits moister and ripening and oil acid percentage. Besides, opened vegetative and flowering buds in the second season after treatments were recorded in Tables from (1 to 6).

It is clear from data in Table (1) that there is marked significant effect for ethephon foliar application in dropped leaves before or after shaking ether in koroneiki or coratina cultivar compared with control treatment. The highest dropped leaves before and after shaking trees recorded with 3500 ppm concentration but no significant differences between 2500 &3500 ppm ethephon concentrations in dropped leaves percentage after shaking in both seasons.

Table 1: Effect of ethephon foliar application on dropped leaves percentage of koroneki and coratina olive cultivars before and after shaking trees during 2015&2016 seasons.

Treatments	% Dropped leaves before shaking		% Dropped leaves after shaking	
	2015	2016	2015	2016
Koroneiki olive cultivar				
Distilled water (control)	1.06 D	1.05 C	1.60 C	1.54 C
Ethephone 1500 ppm	1.45 C	1.16 C	3.10 B	3.23 B
Ethephone 2500 ppm	2.21 B	2.22 B	4.03 A	4.43 A
Ethephone 3500 ppm	2.59 A	2.56 A	4.24 A	4.46 A
Coratina olive cultivar				
Distilled water (control)	1.04 D	1.03 D	2.71 C	2.54 C
Ethephone 1500 ppm	1.43 C	1.41 C	3.73 B	3.56 B
Ethephone 2500 ppm	2.20 B	2.18 B	5.60 A	5.43 A
Ethephone 3500 ppm	2.57 A	2.55 A	5.63 A	5.79 A

Means with the same letter are not significantly different.

Foliar application with ethephon at 3500 ppm caused dropping in leaves before shaking trees estimated by (1.53 & 1.51 % in koroneiki and 1.53 & 1.53 % in coratina) over natural dropping in control in 2015 & 2016 season respectively, but shaking trees treated by 3500 ppm ethephon to fruits harvesting caused dropping in leaves estimated by (2.64 & 2.92 % in koroneiki and 2.92 & 3.25 % in coratina) over control in 2015 & 2016 season respectively.

This leaves abscission come back to the physiological effect of ethephon on abscission layer and make leaves easy to disconnected. This is clear from dropping leaves before shaking. This results are agree with the findings by Yousefi *et al.,* (2010&2012) who indicated that leaf loss was higher than without spraying ethephon. These results were with 3000 ppm concentration. In addition, a positive correlation was found between the total leaf drop and the total harvested fruits percentage.

Regarding to data in Table (2) treating olive trees by ethephon caused a significant abscission in fruits compared with control. Wherever, the highest abscission fruits (5.50 & 4.38 % in koroneiki and 6.5 & 6.05% in coratina cultivar) caused when trees treated by ehephon at 3500 ppm but the least values (3.50 & 2.38 % in koroeiki and 4.50 & 4.05 % in coratina cultivar) recorded from control in the first and second season respectively. Furthermore, the remaining fruits percentage in the phase from application to harvesting decreased by (2%) under control when koroneiki and coratina trees treated by 3500 ppm ethephon in both seasons. This percent (2%) is considered as a loss in yield when using this treatment where it is dropped out before harvesting.

This result is agree with the obtained data by Taleb Abu Zahra, (2014) who found that ethephon foliar application increased fruit abscission, and the highest percentage of fruit abscission recorded with 3000 ppm ethephon treatment and no significant differences with the 4000 ppm treatment.

Table 2: Effect of ethephon foliar application on dropped and remaining fruits percentage of koroneki and coratina olive cultivars before shaking trees during 2015&2016 seasons.

Treatments	% Dropped fruits before shaking		% Remaining fruits before shaking	
	2015	2016	2015	2016
Koroneiki olive cultivar				
Distilled water (control)	3.50 C	2.38 C	96.50 A	97.62 A
Ethephone at 1500 ppm	4.33 B	3.21 B	95.67 B	96.79 B
Ethephone at 2500 ppm	5.17 A	4.05 A	94.83 C	95.95 C
Ethephone at 3500 ppm	5.50 A	4.38 A	94.50 C	95.62 C
Coratina olive cultivar				
Distilled water (control)	4.50 C	4.05 C	95.50 A	95.95 A
Ethephone at 1500 ppm	5.33 B	4.88 B	94.67 B	95.12 B
Ethephone at 2500 ppm	6.17 A	5.72 A	93.83 C	94.28 C
Ethephone at 3500 ppm	6.50 A	6.05 A	93.50 C	93.95 C

Means with the same letter are not significantly different.

Harvesting koroneiki and coratina olive fruits by shaking trees increased by ethephone foliar application as in Table (3) Where the percentage of fruits harvesting gradually increased with the increase of the concentration used and the highest percentage (97.40 & 95.13 % in koroneiki and 90.22 & 88.7 % in coratna cultivar) of fruits harvesting was recorded when trees were shake after treating by 3500 ppm ethephone in 2015 and 2016 seasons respectively. Besides, the remaining fruits on the trees after shaking decreased by ethephone treating where the least fruit remaining percentage (7.53 & 4.87 % in koroneiki and 9.78 & 11.28 % in coratina cultivar) were obtained when trees were shaking after treating trees by ethephone at 3500 ppm in 2015 and 2016 seasons respectively.

These results indicate that ethephon foliar application at 1500, 2500 and 3500 ppm make olive fruits harvesting easy and the best concentration was 3500 ppm which decrease remaining fruits percentage which collecting by hand after shaking trees. This result may be come back to the role of ethephon in decreasing fruit removal force who led to increasing fruit harvesting efficiency by shaking trees. This is agree with the findings by Yousefi *et al.,* (2010), Sessiz *et al*., (2006) and Ozguven *et al*. (2007) who found that the harvesting productivity percentage of the olive fruits increased by using of Ethrel by 3.125 and 6.25 ml/lit by 46 % and 103 %, respectively.

Table 3: Effect of ethephone foliar application on total harvested and remaining fruits percentage of koroneki and coratina olive cultivars after shaking trees during 2015&2016 seasons.

Treatments	% Harvested fruits after shaking		% Remaining fruits after shaking	
	2015	2016	2015	2016
Koroneiki olive cultivar				
Distilled water (control)	29.98 C	29.67D	70.02 A	70.33 A
Ethephone 1500 ppm	69.82 B	76.59 C	15.76 B	23.41 B
Ethephone 2500 ppm	89.93 AB	82.46 B	11.03 C	17.54 C
Ethephone 3500 ppm	97.40 A	95.13 A	7.53 C	4.87 D
Coratina olive cultivar				
Distilled water (control)	48.75 A	47.3 B	51.25 A	52.75 A
Ethephone 1500 ppm	80.63 A	79.1 A	19.37 B	20.87 B
Ethephone 2500 ppm	85.38 A	83.9 A	14.62 B	16.12 B
Ethephone 3500 ppm	90.22 B	88.7 A	9.78 B	11.28 B

Means with the same letter are not significantly different.

Two fruits ripening stage in koroneiki and coratina olive cultivars as affecting by ethephone foliar application were recorded in Table (4) significant effect was found by foliar application of ethephone on green and black fruits percentage during 2015 & 2016 seasons where black fruit percentage increased by all ethephone concentrations compared with control in koroneiki and coratina cultivar. The highest values in this respect (89.00 & 90.00 % in koroneiki and 93.50 & 94.75% in coratina cultivar) were recorded with 3500 ppm concentration in 2015 & 2016 seasons respectively. These treatments lead to decreased green fruits percentage where the lowest values (11.00 & 10.00 % in koroneiki and 6.50 & 5.25 % in coratina cultivar) were obtained from the same treatment in the two seasons too.

This result may be come back to one of ethephon physiological effects on accelerate chlorophyll degradation and enhancing homogeneity fruits ripening it led to improving oil olive qualities. This result is similar with the findings of Royer *et al.,* (2006) and Tsantili & Pontikis, (2004) who reported that ethephon is a synthetic plant growth regulator. It can accelerate chlorophyll degradation and enhance the ripening of in olive fruits

Table 4: Effect of ethephon foliar application on green and black fruits percentage of koroneiki and coratina olive cultivars after treatments during 2015&2016 seasons.

Treatments	% Green fruits		% Black fruits	
	2015	2016	2015	2016
Koroneiki olive cultivar				
Distilled water (control)	49.00 A	48.00 A	51.00 D	52.00 D
Ethephone 1500 ppm	37.33 B	36.33 B	62.67 C	63.67 C
Ethephone 2500 ppm	22.00 C	21.00 C	78.00 B	79.00 B
Ethephone 3500 ppm	11.00 D	10.00 D	89.00 A	90.00 A
Coratina olive cultivar				
Distilled water (control)	44.50 A	43.25 A	55.50 D	56.75 D
Ethephone 1500 ppm	32.83 B	31.58 B	67.17 C	68.42 C
Ethephone 2500 ppm	17.50 C	16.25 C	82.50 B	83.75 B
Ethephone 3500 ppm	6.50 D	5.25 D	93.50 A	94.75 A

Means with the same letter are not significantly different.

Significant decrease in moister percentage of koroneiki fruits cultivar was found from ethephon treatments as in Table (5) but no significant deference between all used concentrations in both seasons. Another trend in coratina cultivar where clear significant difference between the three concentrations was found in both studied seasons. The lowest moister percentage in coratina cultivar fruits (48.47 & 47.27%) recorded with 3500 ppm concentration in 2015 and 2016 seasons respectively.

Furthermore, significant difference in oil acidity percentage in the two studied cultivars except between control and 1500 ppm concentration in the first and second season. The lowest oil acidity

percentage (0.83 & 0.84% in koroneiki and 0.82 & 0.85% in coratina cultivar) recorded with 3500 ppm concentration in 2015 and 2016 seasons respectively.

Decreased oil acidity percent by using ethephon foliar application to make olive fruits harvesting easy may be come back to ease of separation of fruits from branches when shaking without stripping fruits and the role of ethephon on homogeneity fruits ripening. This result is agree with the obtained data by Touss (1995) & Antonia and Agust (2012) who indicated that ethephon had little effect on oil acidity, peroxide value, and oil fatty acid composition.

Table 5: Effect of ethephon foliar application on moister percentage and oil acidity of koroneiki and coratina olive cultivares before during 2015&2016 seasons.

Treatments	Moister percentage		Oil acidity	
	2015	2016	2015	2016
Koroneiki olive cultivar				
Distilled water (control)	53.78 A	54.8 A	0.88 A	0.89 A
Ethephone at 1500 ppm	47.41 B	48.4 B	0.87 A	0.88 A
Ethephone at 2500 ppm	45.21 B	46.2 B	0.85 B	0.86 B
Ethephone at 3500 ppm	45.74 B	46.7 B	0.83 C	0.84 C
Coratina olive cultivar				
Distilled water (control)	59.55 A	58.35 A	0.90 A	0.90 A
Ethephone at 1500 ppm	55.38 AB	54.18 AB	0.87 B	0.89 A
Ethephone at 2500 ppm	50.62 BC	49.42 BC	0.85 BC	0.87 B
Ethephone at 3500 ppm	48.47 C	47.27 C	0.82 C	0.85 C

Means with the same letter are not significantly different.

Concerning to the effect of ethephone foliar application on number of opened vegetative and flowering buds in the next season after treatments as indictor to its effect on vegetative growth and flowering of koroneiki and coratina cultivars. Data in table (6) reveled to although there significantly decrease in vegetative growth and flowering of koroneiki cultivar as a result to ethephon treatments in both seasons but this decrease less than affecting in growth and flowering of koroneiki olive trees. The lowest numbers of vegetative and flowering opened buds recorded with 3500 ppm ethephon were (5.00 & 4.00 in vegetative buds and 22.00 &21.00 in flowering buds) compared with (6.33 & 5.33 in vegetative buds and 24.67 & 23.67 in flowering buds) obtained from control in 2016 &2017 seasons respectively.

Table 6: Effect of ethephon foliar application on number of vegetative and flowering opened buds of koroneki and coratina olive cultivars in 2016&2017 seasons after treatments.

Treatments	Number of vegetative opened buds per branch		Number of flower opened buds per branch	
	2016	2017	2016	2017
Koroneiki olive cultivar				
Distilled water (control)	6.33 A	5.33 A	24.67 A	23.67 A
Ethephone 1500 ppm	6.00 AB	5.00 AB	23.67 AB	22.67 AB
Ethephone 2500 ppm	5.33 AB	4.33 AB	22.67 BC	21.67 BC
Ethephone 3500 ppm	5.00 B	4.00 B	22.00 C	21.00 C
Coratina olive cultivar				
Distilled water (control)	8.17 A	6.67 A	16.000 A	15.00 A
Ethephone 1500 ppm	6.17 B	4.67 B	15.333 A	14.33 A
Ethephone 2500 ppm	6.17 B	4.67 B	13.667 B	12.67 B
Ethephone 3500 ppm	4.83 C	3.33 C	13.667 B	12.67 B

Means with the same letter are not significantly different.

Additionally, this decrease in coratina cultivar was significantly high somewhat with3500 ppm ethephon were (4.83 & 3.33 in vegetative buds and 13.667 &12.67 in flowering buds) compared with (8.17 & 6.67 in vegetative buds and 16.00 & 15.00 in flowering buds) obtained from control in 2016 &2017 seasons respectively. This decrease may be effect on growth and flowering of this cultivar.

In my opinion, the effect of ethephon on vegetative and flowering opened buds in the next year after treatments did not effect on growth and flowering of olive trees. This opinion is agree with Touss (1995) and Antonia & Agust (2012) who reported that using ethephon at 1250 and 1875 mg·liter–1 on conventional 'Arbequina' olive trees increased the yield from mechanical harvesting by 20% and did not adversely affect flowering the following year.

Conclusion

From this study, we can say that spraying with ethephon can solve the problem of olive fruits harvest, especially when using tree-shaking machines, which helps to ease the separation of fruits from branches and improves the homogeneity of maturity, thus reducing the oil acidity. Therefore, we recommend spraying olive trees with ethephon at a concentration of 3500 ppm a week before to make olive fruit harvest easy.

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