Palestine Technical University Research Journal, 2014, 2(1), 09-13
(http://www.ptuk.edu.ps)

Effect of Different Ethephon Concentrations on Olive Fruits Harvesting at Different Orchard Locations

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Received 5 November 2013, Accepted 2 February 2014, Published 9 February 2014

Abstract: An experiment was conducted to determine the optimum ethephon concentration on olive fruit harvesting at different Jordan locations. The study was carried out on Nabali olive cultivar at "Irbid and Ajlon" locations. Treatments were consisted of five ethephon concentrations, which are: 0, 1000, 2000, 3000 and 4000 ppm, each concentration was repeated 4 times. 10 days after ethephon applications, data were collected and analyzed according to the randomized completely block design. Results revealed that all of the used ethephon concentrations promote leaf drop, which remains within the acceptable ranges in both locations. Although, ethephon dosage had significant effects on harvesting productivity at 0.05 levels; best results were obtained by using 3000 ppm concentration at Irbid location, while at Ajlon; best results were observed with treating the olive fruits with 4000 ppm ethephon concentration. On the other hand, positive correlation were observed between the percent of leaf drop and the total harvested fruits

***Keywords*:** Nabali, Ethephon, Fruit Harvesting, Leaf drop, Jordan

Introduction

In the last few decades there has been a significant increase in the global consumption of olive oil, even in countries where it is not produced, such as Canada and Japan (Mili, 2006). This is due to its nutritional and health-promoting effects (Manna et al., 1997).Olive tree orchards are a typical feature of the Mediterranean landscape (Spinelli and Picchi, 2010), and in Jordan; olive trees coversmore than 75 % of areas planted by fruit trees that produced about 221 thousand tons of olive fruits during the year 2011-2012, most of olive fruits are used as source of oil, while 27 % were utilized as naturally ripe olive in brine (Ministry of Agriculture, 2012). Olive fruit harvesting is considered the most expensive stage of olive production; since olive harvesting consumes 50–80 % of the total expenses of growing olive (Metzidakis, 1999). Currently, olives are harvested by the hands in Jordan, expensiveness and provisions of the labor are the main difficulties in the olive harvesting (Dag et al., 2011).

Because the ratio between fruit mass and pedicel's strength is relatively small as compared with other fruits, a huge amount of force is required to shake off the fruits from olive trees (Ben-Tal and Wooder, 1994). Different types of chemicals were tested to promote pedicel's loosening; positive results were only obtained by using the ethylene releasing compounds like ethephon. Ethephon (2-chloroethyl phosphonic acid) is a synthetic plant growth regulator discovered some forty years ago, which acts by releasing ethylene when it penetrates plant tissues (Royer et al., 2006). Ethephon, were found to be able to promote pedicel's loosening and therefore increase the natural ratio between fruit mass and pedicel strength, so olive fruits can be easily mechanically harvested (Denney and Martin, 1994; Martin, 1981; Metzidakis, 1999).Ethephon show non-climacteric behavior and can accelerate chlorophyll degradation in olives (Tsantili and Pontikis, 2004). Many factors can affect ethylene evolution rate like; pH of the water that is used for dissolving the chemical, atmosphere temperature and relative humidity (Beaudry and Kays, 1987).

The percentage of the olive harvesting without using of abscission material was less than 50 % while using of Ethrel with the concentration of 3.125 and 6.25 ml/lit increased the harvesting productivity by 46 % and 103 %, respectively, and decreased the fruit-removal-force (FRF). Besides, using of 2000 ppm of Ethrel to promote the harvesting productivity

through two shaking devices of mechanical and pneumatic types, one month before the olive harvesting has been suggested by Yousefi et al., (2010).

In selecting the timing for harvest, the grower is determining the quantity and quality of the year's fruit, as well as of the next season's crop (Dag et al., 2011). Literature evaluating the simultaneous effect of harvesting time on olive yield and quality are very limited (Beltran et al., 2004). The performance of the harvesting machines largely depends on the binding force the fruit of the stem, or in other words, it is the resistance shown by the fruits when vibrating, that influences the performance of the machines. Using the harvesting machine has the trouble that earlier on the time of natural ripening there are some fruits left over the trees and later on the time of natural ripening, other fruits shed on the ground. To ripen the fruits at the same time and so to promote the harvesting productivity, spraying the fruit trees with a solution which reduces the resistance of the fruit stalks on vibrating moment is recommended for mechanized harvesting (Martin, 1994; Whitney et al. 2000).

Until now, no research project on the mechanized harvesting of the olive and using the abscission chemical has been conducted in Jordan. The objective of this research was to investigate the ways of the Nabali olive harvest using the various amounts of the abscission chemical of Ethephon in the harvesting of two olive orchards locations.

Material and methods

This study was carried out on Nabali olive cultivar at two different orchard locations; the first orchard at Irbid and the second orchard at location was at Ajlon. Both locations were located at the north side of Jordan, and these locations represents the main areas of olive planting in Jordan. At each location, 20 different olive trees of about 10 years old were selected randomly in the field, and were chosen to carry nearly the same amount of yield in the on year. Before treatment applications trees were irrigated with adequate water as recommended by Desouky et al., (2009). Then treatments were applied at early of December, 2012, during the start of purple color formation on the fruit, which considered the normal time for the start of olive harvesting in Jordan. Treatments used were consisted of five Ethephon concentrations; 0 ppm (control), 1000 ppm, 2000 ppm, 3000 ppm, and 4000 ppm, each concentration was repeated 4 times (sprayed on four trees), for each tree four shoots were selected and its leaves and fruits were recorded, then the shoots were covered with a plastic mesh bag to collect the dropped leaves and fruits. Ethephon solutions have been buffered to pH 7 to speed up ethylene release and mitigate olive leaf loss as recommended by Denney and Martin (1994). Ten days after Ethephon applications, the dropped leaves and fruits were collected from each plastic mesh bag, and used for calculating the leaf drop percent and the fruit abscission percent.

After removing the dropped leaves and fruits, the plastic mesh bags were returned to the shoots, then all the trees were shaken with the branch shaking devices (the hand held shaking ones) for about 10 seconds per branch, after that the dropped leaves and harvested fruits were collected from each plastic mesh bag, and used to calculate the percent of the leaf drop after shaking and the percent of harvested fruits.

Measured Parameters

The number of fruits and leaves on each covered branch was recorded, and then all data were collected two weeks after treatments applications and expressed as percentage.

Total leaf drop percent

All of the dropped leaves before and after shaking were counted and divided by the total number of the initial leaves count of the four plastic mesh bags per tree.

Fruit abscission percent

calculated by dividing the number of the collected fruits from the four plastic mesh bags, and divided over the total initial number of fruits of the four covered branches.

Fruit harvesting

after shaking, the dropped fruits percent were calculated by dividing the number of the collected fruits from the four plastic mesh bags, and divided over the total number of fruits that are remained on the branches after removing the dropped fruits before shaking.

Total fruit harvesting percent

All the dropped fruits before and after shaking were counted and divided by the total number of the initial fruits count of the four plastic mesh bags.

Experimental design and statistical analysis

For each experiment location data were collected and analysed separately. A randomized completely block design (RCBD), with five treatments and four replicates (trees) were used. All data obtained were statistically analysed by variance, according to the procedure outlined by Steel and Torrie (1980). The differences between means of the different treatments were compared by the Least Significant Difference (LSD) test using SAS software, and differences with probability value at P = 0.05 were considered significant.

Results and discussion

Leaves drop results

Significant differences were observed among the used ethephon concentrations at Irbid and at Ajlon locations (**Table 1**). The highest significant total leaf drop percent were obtained by the 3000 and 4000 ppm, but these results are lower than 25 % and will not have any harmful effect on the olive trees and its results could be accepted as recommended by Hartmann (1989). So any ethephon concentration could be used depending upon result of fruit harvest percent

Table 1: Olive leaf drop percentage at "Irbid and Ajlon" locations*

Ethephon treatments	Irbid total leaf drop %	Ajlon total leaf drop %
0 ppm (control)	4.6 d**	4.9 c
1000 ppm	7.4 c	7.8 b
2000 ppm	8.5 b	8.1 b
3000 ppm	9.6 a	14.8 a
4000 ppm	9.3 ab	13.6 a
LSD $_{0.05}$	0.82	1.7

* Values are the mean of four replicates.
** Means within each column having different letters are significantly different according to LSD at 5 % level.

Fruits harvesting results

Fruit abscission during the investigation period in the control clusters, was very low (3.8 %) (**Table 2**). The use of the ethephon treatments were found to accelerated fruit abscission, and the highest percentage of fruit abscission (20.2 %) was obtained by the 3000 ppm ethephon treatment without significant differences with the 4000 ppm treatment.

Table 2: Olive fruits chemical harvesting at "Irbid" location

Ethephon treatments	Fruit abscission % before shaking	Fruit harvesting % after shaking	Total fruit harvesting %
0 ppm (control)	3.8 c**	21.5 c	28.38 c
1000 ppm	9.8 b	30.8 b	50.16 b
2000 ppm	11.0 b	34.1 b	51.37 b
3000 ppm	20.2 a	44.5 a	71.00 a
4000 ppm	17.1 a	41.1 a	66.92 a
LSD $_{0.05}$	3.7	4.5	5.7

*** Values are the mean of four replicates.**
**** Means within each column having different letters are significantly different according to LSD at 5 % level.**

Also, after shaking 3000 ppm ethephon treatment produced the highest fruit harvesting without significance with 4000 ppm treatment. When considering the total fruit harvesting; all of the used ethephon concentrations were found to promote olive fruit harvesting compare to the control treatment which produced the lowest significant fruit harvested. Best results of fruit harvesting (71 and 66.92 %) were obtained by the 3000 and 4000 ppm, respectively. Therefore, ethephon has performed well as a fruit-harvesting agent for Nabali olive fruit harvesting at Irbid location and results obtained here showed that ethephon at 3000 ppm could be used in olive fruit harvesting at this location. And these results are in agreement with that obtained by Abeles et al. (1992) and Ban et al. (2007).

Results of Ajlon location (**Table 3**) proved that ethephon application treatments promoted fruit abscission; the highest percent (33.2 %) of fruit percentage was obtained by the 4000 ppm, while the lowest was obtained by the control treatment with 4.75 %. On the other hand, after shaking the highest fruit harvesting percent were observed between 3000 and 4000 ppm treatments, but without significant differences. In contrast, all ethephon treatments increased the total fruit harvesting percent in comparison with the control treated olive trees, and the highest significant total fruit percent (84.1) was obtained by the 4000 ppm ethephon concentration. Therefore, at Ajlon location the 4000 ppm ethephon concentration could be used as a harvesting agent.

Table 3. Olive fruits chemical harvesting at "Ajlon" location

Ethephon treatments	Fruit abscission % before shaking	Fruit harvesting % after shaking	Total fruit Harvesting %
0 ppm (control)	4.75 d	25.66 c	35.7 d
1000 ppm	14.30 c	31.85 bc	51.85 c
2000 ppm	11.43 c	36.40 b	54.48 c
3000 ppm	20.60 b	47.70 a	71.74b
4000 ppm	33.20a	54.68 a	84.10a
$LSD_{0.05}$	3.8	8.6	9.1

***: Values are the mean of four replicates.**
****: Means within each column having different letters are significantly different according to LSD at 5 % level.**

On the other hand results for the percent of leaf drop and the total harvested fruits, showed a significant positive correlations within all the olive orchard locations (**Table 4**).

Table 4. Correlations between total leaf drop percent and total fruit harvesting percent in both locations

Location	Correlation of total leaf drop % to Total fruit harvest %
Irbid	0.968
Ajlon	0.938

Conclusion

Our research indicates that all of the applied ethephon concentrations accelerates leaf drop percent, and all of the used concentrations are acceptable at both locations. In contrast, the obtained results of fruit harvesting, showed that ethephon at 3000 ppm could be used in olive fruit harvesting at Irbid orchard location, but at Ajlon location, best results were obtained by using 4000 ppm of the ethephon. In addition, for fruit harvesting, spraying the fruit trees with a solution which reduces the resistance of the fruit stalks on vibrating moment is recommended for mechanized harvesting. Also, positive correlations were found between the total leaf drop percent and the total harvested fruits of both locations.

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