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Effect of some Preharvest Treatments on Fruit Drop, Quality and Shelf Life of "Anna" Apple Fruits

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ABSTRACT

This work was carried out during 2018 and 2019 seasons for studying the effects of pre-harvest treatment by Aminoethoxyvinylglycine (AVG), 1-Naphthaleneacetic acid (NAA), P-Coumaric acid and Lyso–phosphatidylethanolamine (lisophos) on preharvest drop, fruit quality and fruit shelf life of 'Anna' apple fruit. Seven treatments used as foliar application of AVG at 300 ppm, AVG at 300 ppm plus P-Coumaric acid at 50 mM or lisophos at 400 ppm, NAA at 20 ppm, NAA at 20 ppm plus P- Coumaric acid at 50 mM or lisophos at 400 ppm and water application as a control were applied. Results showed that application of AVG or AVG plus lisophos reduced preharvest fruits drop and increased yield, fruit firmness, acidity, starch and chlorophyll (a, b) contents as compared with control and other treatments in both seasons. On the other hand, fruit weight, size, length and diameter were increased by NAA or NAA plus lisophos relative to the control and other treatments in both seasons. Also, spraying NAA followed by P-coumaric acid significantly increased fruit drop%, SSC, total sugars and anthocyanin contents but decreased fruit firmness during both seasons. Concerning shelf life period, all preharvest of AVG treatments significantly decreased the loss % of firmness, fruit weight loss, fruit decay %, SSC and anthocyanin contents compared to other treatments. it could be concluded that, pre harvest foliar application with AVG at 300 ppm alone or followed by lisophos at 400 ppm reduced preharvest fruits drop % and fruit decay % and increased yield and fruit firmness. Thus, both treatment are recommended for apple growers to obtain the best yield and prolong the handling season with acceptable fruit coloration.

Keywords: Apple, AVG, NAA, lisophos, P- Coumaric acid, fruit drop, fruit quality, shelf life.

INTRODUCTION

Apple (*Malus domestica* Borkh.) is an important member of family Rosaceae and one of the most popular fruits in many regions and cultures around the world. The cultivated area with apple in Egypt is 30363ha, which produces about 798574tonnes according to (FAO, 2017).

In Egypt, many challenges are facing apple production for high productivity and good quality. Preharvest fruit drop (PFD) is considered one of the most challenge of apple production especially in new reclaimed regions such as Wadi Elnatroon and Nubarria, which causing the greatest reduction in fruit yield. It occurs very rapidly just before starting fruit color development. Thus, producers sometimes resort to early-harvest to prevent fruits drop (Petri *et al*., 2006) but in this case, apple fruits are smaller in the size and poor in the quality which are causing reduction of total income because of the low fruit quality will be sold in a cheaper price (Greene, 2002& Yuan and Carbaugh, 2007).Plant stress and premature ethylene production are the basis of true physiological drop (Ward *et al*., 1999). Ethylene is a plant hormone that promotes fruit ripening and abscission by synthesizing and activation of hydrolytic enzymes that break down the cell walls in the abscission zone (Yuan and Carbaugh, 2007).Moreover, fruits drop down increase when the concentration of auxins decreases and the concentration of abscisic acid increases (Marinho *et al.*, 2005).

Some plant growth regulators are effective in reducing preharvest drop. They are very different compounds with respecting the mode of action, optimal time application, and their effects on fruit quality. NAA as a synthetic auxin is considered the only auxin registered for controlling of pre-harvest drop and it is used commercially in California for reducing premature fruit drop in 'Bartlett' pears (Clayton *et al*., 2000).Moreover, NAA is used at rates between 5 and 20 mg l^{-1} and it should be applied before significant drop begun. Many of the failures trials of NAA application to retard fruit drop can be attributed to late application, when drop is already under way (Raja *et al*., 2017).

Over the years, there are many attempts to neutralize the influence of ethylene by using safe compounds that interfere with the pathway of ethylene biosynthesis such as aminoethoxyvinylglycine (AVG) (Bramlage *et al*., 1980). AVG can be blocked ethylene synthesis which inhibit the conversion of S-adenosyl methionine to 1-aminocyclopropane-1-carboxylic acid (Yang & Hoffman, 1984). It is a friendly used for human and environment and it is commercially applied under the name of ReTain®, for delaying the ripening of apple fruits(Greene and Schupp, 2004). In 'Golden Delicious' apples, applying of AVG four weeks before harvesting inhibited ethylene production, reduced preharvest drop and delayed fruit ripening (Autio and Bramlage, 1982). However, AVG might impair fruit quality by inhibiting volatiles production (Mir *et al*., 1999). Finally, AVG delayed apple fruit drop as well or better than auxin compounds (Bangerth, 1978).

Due to the little differences between day and night temperatures in Egypt, orchards of "Anna" apple suffer from poor fruit coloration. Thus, growers usually use Ethephon to increase anthocyanin biosynthesis in apple skins (Atay *et al*., 2012),but negative effect is associated with ethephon application such as acceleration of ethylene biosynthesis (Derhab, 2015).Application of some compounds such as "p-coumaric" acid and lisophos (Lyso –phosphatidylethanolamine) can be used to antagonize the negative effect of ethylene. Para-coumaric acid plays an important role in anthocyanin biosynthesis pathway, it converts to p-coumarylco A which converted through many steps in the presence of some enzymes to anthocyanin (Mattivi *et al.*, 2006).

Lysophosphatidylethanolamine (LPE) is a natural product of membrane phospholipid metabolism and it is formed from phosphatidylethanolamine (PE) by action of phospholipase A2.It is remains in the lipid phase because LPE has a hydrophobic group such as fatty acid. It has been shown to control and manage quality of flowers, fruits, and other horticultural products. Previous studies showed that, LPE can accelerate ripening of cranberry fruits while prolong shelf-life at the same time (Farag and Palta, 1993,b).Furthermore, it inhibited ethylene production and maintained fruit firm thereby prolong shelf life. LPE can also accelerate color development of cranberries (Ozgen *et al*., 2004).Moreover, LPE enhanced phenylalanine ammonia-lyase in radish cotyledons (Hong *et al*., 2009a).LPE Also reduces the activity of phospholipase D and membrane leakiness (Hong *et al*., 2009b).

The present investigation aimed to reduce preharvest drop of fruits, enhance fruit coloration and extend the shelf life of Anna apple fruits without scarifying the quality by application of AVG, NAA, P-Coumaric acid and lisophos compounds.

MATERIALS AND METHODS

The present investigation was conducted during the two successive growing seasons 2018 and 2019 on Anna apple trees (*Malus domestica*, Borkh), six years old budded on ‘Balady’ rootstock and grown in a private orchard at El - Nobaria district, El Beheira governorate. Sandy soil, well drained and the depth of water table was at least under 1.5 meters. Trees were healthy, uniform and free of defects. The orchard trees were spaced at 4 x 5 m; opened center trained and irrigated with drip irrigation system. All trees of this experiment received the same recommended and the regular horticultural practices for this region. This experiment consisted of seven treatments, four replicates for each, one tree for each replicate arranged in randomized complete blocks design (RCBD). The treatments were as following:

1. Control(spraying water only).
2. AVG at 300 ppm
3. NAA at 20 ppm
4. AVG at 300 ppm + P- Coumaric acid at 50 mM
5. AVG at 300 ppm + Lisophos 400 ppm
6. NAA at 20 ppm+ P- Coumaric acid at 50 mM
7. NAA at 20 ppm+ Lisophos 400 ppm

All treatments were applied by a hand sprayer set to run off. The trees were sprayed with AVG and NAA on 24th, 26thApril during 2018 and 2019 seasons, respectively-Coumaric acid and Lisophos were applied three weeks before commercial harvesting time (at the beginning of fruit color break) on 15th and 17th May 2018 and 2019, respectively. The non-ionic surfactant Tween 80 at 0.05% (v/v) was added to all treatments to reduce the surface tension and increase the contact angle of sprayed droplets.

Preharvest fruit drop%:

Preharvest fruit drop%: percentage was calculated using the following equation;

$$\text{Fruit drop \%} = \frac{\text{Initial fruit number (after fruit set)} - \text{Final fruit number (At harvest)}}{\text{Initial fruit number}} \times 100$$

Yield (kg/ tree) :

Yield per each tree was calculated by multiplying average fruit weight and number of fruits at harvest.

Fruit physical and chemical properties:

Samples of 30 fruits were randomly collected from each replicate at harvest date (7th, 9 th June in 2018 and 2019, respectively), then each sample divided into two groups. The first one used in order to determine the effect of the different treatments on fruit quality characteristics (physico-chemical characteristics) at harvest. Meanwhile, the fruits of the second group, fruits were held at room temperature (22 ± 1°C) for 10 days in order to determine the effect of the different treatments on fruit shelf life. The following parameters were studied on the experimental plants:

a- Fruit physical properties:

A sample of ten fruits from each replicate was weighed and the average weight of the fruit was calculated. Fruit size (cm^3)was determined by displacement in cylindrical tube containing tap water. Fruit dimensions (length and diameter) were measured by using a Vernier caliper. Fruit firmness as (lb/Inch^2), was determined by using Effigi pressure tester mod. FT 327 (scale of, 3-27 Lbs.) according to Magness and Taylor (1982).

b- Fruit chemical properties

In order to determine the Fruit chemical properties, 10 fruits from every replicate were used. Fruit juice was extracted by homogenising fruit flesh in a blender and soluble solid content (SSC) % of the juice was measured bya hand-refractometer. Fruit juice acidity was determined as mg malic acid /100 ml juice by titration with 0.1N sodium hydroxide solution of a known normality using phenolphthalein as an indicator and expressed as percent malic acid according to A.O.A.C.(1995). Total sugars were determined by using the phenol sulfuric acid method outlined by Malik and Singh, (1980).Starch content was determined in the residue remained after sugars extraction. 0.1 gram of the residue was hydrolyzed with concentrated HCL for three hours under reflux condenser (A.O.A.C., 1995) and reducing potential of the hydrolysis was determined by the arsenate-molybadate method. A factor of 0.9 was used to calculate starch (Wood man 1941). Anthocyanin was extracted from 1.0 g fruit fresh peel from color cheek and extracted by using 20 ml of the extraction solution (85% ethyl alcohol 95% + 15% HCL 1.5N) and anthocyanin content as mg/100g fresh weight was measured by photoelectric colorimeter at 535 nm, according to the method of Fuleki and Francis (1968).Also, 0.5 g fruit fresh peel was extracted with 15ml acetone (85%) and 0.5g calcium carbonate for chlorophyll determination and chlorophyll (a) and (b) contents were determined calorimetrically at a wave length of 662 and 644 nm, respectively using Spectrophotometer as described by Wintermans and Mats (1965).

Fruit decay %:

Fruits affected by either pathological or physiological disorders were counted by visual and calculated as a percentage to the initial number of fruits per each sample.

Measurements after shelf life:

Fruit samples were washed, dried and placed under room temperature in the laboratory at (22±2 °C) for ten days. The following parameters were determined:

Fruit weight and fruit firmness losses %:

Fruit weight and fruit firmness losses were determined according to the following equations respectively:

$$\text{Fruit weight loss \%} = \frac{\text{Initial weight (at the beginning of shelf life) - Average final weight (at the end of shelf life)}}{\text{Average initial weight}} \times 100$$

$$\text{Fruit firmness loss \%} = \frac{\text{Average initial firmness-Average final firmness}}{\text{Average initial firmness}} \times 100$$

Furthermore fruit decay %, SSC in fruit juice and peel anthocyanin content were determined as previously mentioned.

Statistical design and analysis

This experiment consisted of 7 treatments arranged in a randomized complete block design with four replicates for each treatment and one tree for each replicate. Comparisons among means were made via the Least Significant Differences (LSD) at 0.05 level of significance according to Snedecor and Cochran (1989). The data were analyzed using Statistical Analysis System(SAS, 2000) program.

RESULTS AND DISCUSSION

Results

Effect of AVG, NAA, P- Coumaric acid and Lisophos application on fruit drop %, yield and firmness:

The results in Table (1) represented the effect of spraying various treatments on preharvest fruit drop %, yield and firmness of' Anna" apple trees during 2018 and 2019seasons. The obtained data cleared that all the formulations containing AVG reduced preharvest fruit drop % as compared with NAA treatments and control. Furthermore, AVG at 300 ppm significantly decreased preharvest fruit drop during both seasons as compared with other treatments except treatment No. 5 (spraying AVG at 300 ppm + Lisophos at 400 ppm) in both seasons. Spraying NAA only or pus LPE resulted in a significant decrease in preharvest fruit drop relative to the control and NAA + P-coumaric acid in both seasons. Moreover, the highest percentage of "Anna" apples drop was found with control treatment in both seasons.

As for the effect of tested treatments on yield, the statistical analysis in Table (1) cleared that the differences among the used treatments were significant. Moreover, the yield of trees treated with AVG at 300 ppm alone or plus Lisophos at 400 ppm as well as NAA at 20 ppm plus Lisophos at 400 ppm was higher than other treatments in both seasons.

Regarding fruit firmness (Table 1), spraying AVG at 300 or AVG plus lisophos tended to increase fruit firmness at harvest as compared with the other treatments in both seasons. Moreover, applying the combination of AVG plus coumaric acid caused a significant increase in fruit firmness as compared with control in both seasons. In addition, NAA alone or plus lisophos or coumaric acid did not significally affect fruit firmness compared with control in the second season.

Table 1. Effects of preharvest spraying of AVG, NAA, P- Coumaric acid and Lisophos on fruit drop (%),Yield kg/tree and firmness (lb / Inch^2) of "Anna" apple trees at harvest in 2018 and 2019 seasons.

Treatments	Fruit drop (%)		Yield kg/tree		Firmness (lb/Inch²)	
	2018	2019	2018	2019	2018	2019
Control	19.83a	18.09a	41.92e	44.87 b	11.523c	12.11cd
AVG at 300 ppm	4.99e	6.313f	48.49a	52.42 a	13.586a	14.16a
NAA at 20 ppm	14.38b	12.13c	47.02bc	49.96ab	12.123b	12.53bc
AVG at 300 ppm + P- Coumaric acid at 50 mM	9.04d	10.45d	46.17 cd	49.52ab	12.423b	12.91b
AVG at 300 ppm + Lisophos at 400 ppm	6.76e	7.74e	48.05ab	51.59a	13.490a	14.10a
NAA at 20 ppm+ P- Coumaric acid at 50 mM	14.53b	14.62b	45.78 d	49.28 ab	11.070c	11.57d
NAA at 20 ppm+ Lisophos at 400 ppm	11.46c	12.55c	48.59 a	52.34a	12.083b	12.45bc
LSD at $_{0.05}$	2.119	0.75	0.71	5.88	0.794	0.712

Effect of AVG, NAA, P- Coumaric acid and Lisophos application on fruit weight, size and dimension:

Data illustrated in Table (2) showed the application of NAA alone or followed by lisophos led to increase in fruit weight in both seasons when compared with the other treatments. Moreover, spraying NAA followed by coumaric acid caused a significant increase in fruit weight relative to the control and all treatments containing AVG in both seasons. On the other hand, the application of AVG individually or with combinations markedly decreased fruit weight compared to control in both seasons.

Data in Table (2) showed that, all AVG treatments did not cause a significant change in fruit size in both seasons relative to the control. Furthermore, spraying of NAA alone or followed by coumaric acid or lisophos significantly increased fruit size in comparison with other treatments.

The obtained data in Table 2 cleared that fruit dimension markedly increased with all treatments containing NAA relative to AVG treatments and control. Generally, the highest fruit dimensions were noticed with the application of NAA at 20 ppm in both seasons, meanwhile the lowest fruit dimensions were observed with the treatments with AVG alone or plus coumaric acid or lisophos.

Table 2. Effects of preharvest spraying of AVG, NAA, P- Coumaric acid and Lisophos on fruit weight, fruit size, fruit length and fruit diameter of "Anna" apple trees at harvest in 2018 and 2019 seasons.

Treatments	Fruit Weight (gm)		Fruit Size (cm^3)		Fruit Length (cm)		Fruit Diameter (cm)	
	2018	2019	2018	2019	2018	2019	2018	2019
Control	174.70c	175.5d	103.60bc	105.79bc	7.75c	7.84b	5.72c	6.22cd
AVG at 300 ppm	169.10e	171.88e	98.15d	100.37d	7.65e	7.73c	5.66d	6.09d
NAA at 20 ppm	182.67a	182.40b	108.33a	113.36a	7.86a	7.93a	5.91a	6.52a
AVG at 300 ppm + P- Coumaric acid at 50 mM	169.74de	169.58f	98.89d	102.22cd	7.66e	7.69c	5.64d	6.11d
AVG at 300 ppm + Lisophos at 400 ppm	171.41d	172.95e	03.43c	105.85bc	7.71d	7.71c	5.65d	6.17d
NAA at 20 ppm+ P- Coumaric acid at 50 mM	178.16b	180.30c	105.67b	107.86b	7.82b	7.86ab	5.7c	6.36bc
NAA at 20 ppm+ Lisophos at 400 ppm	182.23a	184.78a	108.19a	111.27a	7.83b	7.85ab	5.78b	6.43ab
LSD at $_{0.05}$	1.859	1.879	2.121	3.003	0.018	0.08	0.039	0.14

Effect of AVG, NAA, P- Coumaric acid and Lisophos application on chemical properties:

The data in Table (3) indicated that generally the application of NAA + coumaric acid significantly increased SSC % compared to control and other treatments. Moreover, NAA alone or + lisophos markedly increased SSC compared to AVG alone or in combined with coumaric acid or lisophos. Meanwhile, the addition of AVG led to a significant reduction in fruit SSC when compared to other treatments.

The data in Table (3) showed that, the lowest fruit acidity was obtained with the use of NAA at 20 ppm plus coumaric acid at 50 mM for the both seasons. Furthermore, NAA alone or plus lisophos applications tended to reduce acidity relative to control or AVG treatments.

Also, total sugars and starch content data generated from the influence of various applied treatments before-harvest was reported in table 3. The data revealed that a significant increase in total sugars content with the treatment of NAA at 20 ppm plus coumaric acid at 50 mM in both seasons. In the meantime, NAA application alone or with lisophos was not effective in terms of the response of total sugars content when compared with the control. Furthermore, all AVG treatments caused a noticeable reduction in total sugars content.

The treatments with AVG alone or with lisophos had significantly increased fruit starch at harvest as compared with the other treatments in both seasons but the differences between them were not big enough to be significant.

Table 3. Effect of preharvest spraying of AVG, NAA, P- Coumaric acid and Lisophos on fruit SSC, acidity, total sugars and starch of "Anna" apple trees at harvest in 2018 and 2019 seasons.

Treatments	SSC (%)		Acidity (%)		Total sugars (%)		Starch (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
Control	11.93c	12.90b	0.656c	0.633cd	9.65bc	9.86b	1.74d	1.963b
AVG at 300 ppm	10.37d	10.50d	0.876a	0.916a	8.46d	8.98d	2.31a	2.516a
NAA at 20 ppm	12.53ab	12.83b	0.656c	0.776b	9.76b	9.96b	1.82cd	2.046b
AVG at 300 ppm + P- Coumaric acid at 50 mM	10.53d	10.96c	0.746b	0.806b	8.69d	8.98c	2.09b	2.436a
AVG at 300 ppm + Lisophos at 400 ppm	10.50d	10.52d	0.780b	0.820b	8.47d	9.06c	2.26a	2.516a
NAA at 20 ppm+ P- Coumaric acid at 50 mM	12.73a	14.60a	0.630c	0.616d	10.13a	10.33a	1.89c	2.063b
NAA at 20 ppm+ Lisophos at 400 ppm	12.30b	12.70b	0.660c	0.686c	9.42c	9.73b	1.81cd	1.996b
LSD at $_{0.05}$	0.290	0.330	0.0706	0.063	0.336	0.255	0.125	0.185

Chlorophyll (a and b)and Anthocyanin contents

From the data in Table (4), ,fruit treated by AVG treatments possessed the highest chlorophyll a and b contents among all other treatments in both seasons. The lowest chlorophyll a content was found with NAA plus coumaric acid treatment as compared with the other treatments in both seasons.

The data in Table (4) showed the influence of various used treatments on anthocyanin content, the application of NAA alone or combing with coumaric acid or lisophos significantly increased peel anthocyanin content as compared with the control or AVG treatments in both seasons. Moreover, AVG alone at 300 gave the lowest values of anthocyanin content.

Fruit decay %

Fruit decay % data Table (4), indicated that all treatments significantly decreased fruit decay % as compared to control in both seasons. The highest reduction of fruit decay was noticed with the application of AVG at 300 ppm. The application of AVG alone or plus coumaric acid or lisophos markedly decreased fruit decay % as compared with all NAA treatments in both seasons.

Table 4. Effect of preharvest spraying of AVG, NAA, P- Coumaric acid and Lisophos on Chlorophyll (a, b), anthocyanin contents and fruit decay of "Anna" apple trees at harvest in 2018 and 2019 seasons.

Treatments	Chlorophyll a (mg/100 g fruit peel)		Chlorophyll b (mg/100 g fruit peel)		Anthocyanin (mg/100 g)		Fruit decay (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
Control	0.633c	0.680c	0.337c	0.349e	16.62c	17.18c	10.19a	9.41a
AVG at 300 ppm	0.780a	0.820a	0.421a	0.462a	10.99e	11.66f	1.33e	1.23f
NAA at 20 ppm	0.636c	0.666c	0.351c	0.388cd	17.93b	18.34b	6.436c	5.50c
AVG at 300 ppm + P- Coumaric acid at 50 mM	0.720b	0.753b	0.397ab	0.4273ab	15.55c	15.85d	4.670d	3.50d
AVG at 300 ppm + Lisophos at 400 ppm	0.717b	0.716bc	0.387b	0.420bc	13.74d	13.89e	4.016d	2.66e
NAA at 20 ppm+ P- Coumaric acid at 50 mM	0.560d	0.586d	0.342c	0.376de	19.42a	20.10a	7.23b	6.46b
NAA at 20 ppm+ Lisophos at 400 ppm	0.620c	0.660c	0.341c	0.373de	18.20b	19.85a	6.566bc	5.63c
LSD at $_{0.05}$	0.035	0.066	0.0303	0.0361	1.116	1.160	0.688	0.458

2. Effect of preharvest spraying of AVG, NAA, P-Coumaric acid and Lisophos on fruit firmness loss %, fruit weight loss, fruit decay, anthocyanin content and fruit SSC of "Anna" apple trees at the end of shelf life for 2018 and 2019 seasons

The effect of preharvest application of various used treatments on the percentage of fruit firmness loss of "Anna" apple fruits after 10 days of shelf life at 22˚ C in 2018 and 2019 seasons are reported in Table 5.For the both seasons, all treatments caused a significant reduction in firmness loss % relative to the control. Moreover, all the formulations containing AVG were superior in their effect on reducing fruit firmness loss % as compared with NAA treatments and control. Furthermore, the application of AVG at 300 ppm or followed by lisophos significantly decreased firmness loss percentage during both seasons as compared to other treatments. In addition, the treatment with AVG followed by coumaric acid led to decrease firmness loss %relative to control and all NAA treatments during two seasons.

Table 5. Effect of preharvest spraying of AVG, NAA, P- Coumaric acid and Lisophos on fruit firmness loss, fruit weight loss, fruit decay, anthocyanin content and fruit SSC of "Anna" apple trees at the end of shelf life in 2018 and 2019 seasons.

Treatments	Fruit firmness loss (%)		Fruit weight loss (%)		Fruit decay (%)		SSC (%)		Anthocyanin (mg/100 g)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Control	59.08a	57.70a	2.85a	2.56a	30.13a	27.14a	13.20a	13.86a	19.563c	19.18cd
AVG at 300 ppm	27.15e	25.77e	1.61e	1.28e	6.210g	5.833f	11.33b	11.50c	13.08e	13.65f
NAA at 20 ppm	43.39b	42.01b	2.103c	1.81c	16.71d	17.77c	13.40a	13.53ab	19.66c	20.34bc
AVG at 300 ppm + P- Coumaric acid at 50 mM	32.02d	30.64d	1.85d	1.56d	14.073e	14.37d	11.53b	11.63c	17.68d	17.85d
AVG at 300 ppm + Lisophos at 400 ppm	30.46de	29.08de	1.57e	1.28e	9.83f	10.55e	11.63b	11.76c	16.81d	15.89e
NAA at 20 ppm+ P- Coumaric acid at 50 mM	44.57b	43.19b	2.46b	2.17b	18.726c	18.12c	13.50a	13.56ab	23.53a	22.76a
NAA at 20 ppm+ Lisophos at 400 ppm	38.65 c	37.26c	1.99c	1.69c	20.92b	20.61b	13.36a	13.30b	21.66b	21.18b
LSD at $_{0.05}$	3.586	3.585	0.118	0.117	1.135	1.482	0.396	0.549	1.264	1.54

The trend of various treatments effect on weight loss % was nearly similar to their effect on firmness loss percentage where spraying AVG alone or + lisophos significantly decreased fruit weight loss % compared to all NAA treatments without significant differences between the two treatments of AVG (Table 5). Moreover, foliar application of AVG followed by coumaric acid was also effective in decreasing loss of weight relative to control and NAA treatments in both seasons. All treatments markedly decreased fruit weight loss % compared to control for the both seasons.

With respect to the effect of various applied treatments on fruit decay % of "Anna" apple fruits at the end of shelf life period, the data demonstrated in Table (5) declared that, all treatments significantly reduced the incidence of fruit decay after keeping for 10 days at room temperature as compared to the control. Furthermore, the individual application of AVG was able to decrease fruit decay in a considerable manner relative to other treatments in both seasons. Moreover, applying the combination of AVG plus coumaric acid or lisophos tended to decrease fruit decay as compared to NAA treatments and control.

The data in Table (5) indicated that, NAA treatments and control tended to increase fruit SSC when compared with application of AVG treatments for the both seasons. Moreover, the differences between NAA treatments were not significant.

All the formulations containing NAA were superior in their effect on anthocyanin content as compared to the control and AVG treatments for the both seasons (Table 5). Moreover, applying NAA +coumaric acid gave the greatest anthocyanin content relative to other treatments in both seasons. In addition, spraying NAA only or with lisophos led to a marked increase in fruit skin anthocyanin content as compared with control and AVG treatments for the both seasons. On the other hand, applying AVG or AVG plus lisophos significantly decreased anthocyanin content relative to control.

Discussion

Ethylene is a plant hormone which is considered a main factor controlling abscission and fruit drop (Brown, 1997).It is a potent inhibitor of auxin transport and stimulates synthesis and activity of hydrolytic enzymes such as polygalacturonase, cellulase and pectin methyl-esterase that break down the cell walls in the abscission zone of the stem leaving the fruit connected to the tree by only the vascular strands, which are easily broken (Bonghi, *et al*., 1992). So, using stop drops like AVG and NAA to decrease ethylene biosynthesis would be useful to decrease fruit drop.

In this experiment, Reduction in preharvest fruit drop might be due to the fact that AVG inhibit ACC synthase, it is a key enzyme to control biosynthesis of ethylene (Jobling *et al*. 2003). AVG, also, delayed the onset ethylene climacteric of apple fruit and makes it seem a likely tool for inhibiting abscission (Autio and Bramlage, 1982). Meanwhile, NAA used to reduce pre-harvest drop by correcting the deficiency of endogenous auxin thereby inhibition of hydrolytic enzymes (Marini *et al*., 1993).

In the present study, Reduction in preharvest fruit drop could explain the increase in yield resulted from trees treated with AVG alone or plus lisophos ,while the effect of NAA plus lisophos treatment in improving yield directly associated with fruit weight .

The present results are in conformity with the findings of Yildiz, *et al*., (2012)on 'Red Chief' apple. They reported that AVG applications significantly decreased preharvest drop ratio relative to control. Also, Özturk *et al*., (2015) stated that, AVG was found to be more effective in controlling pre-harvest drops than NAA on 'Jonagold' apples. On the other hand, Dussi *et al*. (2002)reported that preharvest application of AVG on Bartlett pear trees did not control preharvest fruit drop.

The improvement in fruit physical properties as a result of NAA could be attributed to the role of NAA in increasing the fruit size by stimulating cell division, cell elongation and cell enlargement. It is also increasing the enlargement of vacuoles and reducing pressure of cell wall and increasing cell-wall elasticity and plasticity (Agrawal and Dikshit, 2008).Further, NAA increased volume of intercellular space in the mesocarpic cells and enhanced absorption of water, mobilization of sugars and minerals in the expanded cells and intercellular space. Kumar *et al*. (2010) reported that amylase activity, membrane permeability and strength of carbohydrate sink was increased by applied NAA. Moreover, it increased fruit weight by the strengthening of middle lamella and consequently cell wall, which later may have increase the free passage of solutes to the fruits(Desai *et al*, 1993) .This action may led to more length and diameter of fruit and also larger weight of individual fruit. The present results are in harmony with those previously reported by Jain and Dashora, (2010) on guava fruits.

The above findings on both fruit length and fruit diameter agreed with the results of Tabatabaeefar and Rajabipour (2005) who reported that the average fruit length and width was increased with AVG treatment for Red Delicious and Golden Delicious apple fruits. Also, Greene (2006)reported that AVG might indirectly affect the fruit size by delaying ripening. In addition, Özturk *et al*. (2012)found that AVG increased fruit length and width of 'Braeburn' apple fruits.

Flesh firmness is an important character regarding shelf life and storability in apples fruit. Many researchers reported that pre-harvest AVG treatments delayed fruit ripening and flesh softening of apples (Greene, 2005).The increase in fruit firmness as a result of AVG treatments may be due to AVG have the ability to reduce respiration rate, ethylene production, result in lower cell wall degrading enzyme activity (Payasi *et al*., 2009). The present results are in harmony with those previously reported by Amarante *et al*., (2002) on Gala and Fuji apples and Yildiz, *et al*., (2012) on 'Red Chief' apple, they found that the loss of fruit firmness reduced by AVG sprays. In addition, Yuan and Carbaugh, (2007) and Özturk *et al*., 2015) on different apple cultivars decided that fruits treated with AVG often had higher firmness than those treated with NAA.

Treating fruits with LPE after AVG significantly increased fruit firmness due to LPE can maintain the plasma membrane integrity and mitigated the effect of ethylene on the cell wall or membranes lipid degradation (Farag and Palta, 1993a). Moreover, LPE retarded polygalacturonase-mediated fruit softening (Hong *et al*., 2008) and reduced activity of phospholipase D. The obtained results concerning this effect are in agreement with the findings of Farag and Attia (2016).

The increase in the SSC and total sugar contents and decrease acidity and starch contents by NAA application may be attributed to facts that NAA is beneficial in the process of photosynthesis which leads to the accumulations of oligosaccharides and polysaccharides, this also regulators the enzymes that metabolize the carbohydrates from the source to sink (fruits) into simple sugars, also, increase "a-amylase activity. So, there was a conversion of starch into sugars and then improved SSC and total sugar content(Greene and Schupp, 2004 and Karole, 2014). The higher starch degradation might be related to induce increment in metabolic activity that would also include the conversion of starch into soluble sugars(Sigal-Escalada, 2006). Decreasing SSC and total sugars due to AVG application may be due to slowing down the conversion of starch into sugar by inhibiting biosynthesis of ethylene (Greene, 2002; Greene and Schupp, 2004 and Yuan and Carbaugh, 2007). Meanwhile, increasing acidity by AVG could be attributed to delaying the ripening process and reducing respiration of fruits (Sigal-Escalada, 2006). The above results are also confirmed with those of Fallahi, (2007), Yildiz,*et al*., (2012) and Özturk *et al*., (2015) on different apple species

The decrease of anthocyanin and increase of chlorophyll a and b contents as a result of AVG applications may be due to that AVG delays the ripening and colour formation of fruits (Greene and Schupp, 2004). These results are in harmony with those obtained by Clayton *et al*., (2000) and Özturk *et al*., (2015). In addition, treating fruits by coumaric acid after NAA increased anthocyanin and decreased chlorophyll a and b contents. Such effect might be due to that coumaric acid is involved in the activation of chlorophyllase that break down chlorophyll(El-Abd, 2011).Moreover, coumaric acid is an important step in the pathway leading to the formation of anthocyanin (El-Abd, 2011).

Concerning shelf life period, spraying AVG alone or followed by LPE showed a reduction of weight loss, firmness loss and fruit decay percentages, such effect probably due to AVG is an inhibitor of ethylene synthesis. It also plays a protective role on fruit peel integrity and softening, so reduced respiration rate, cell wall softening enzyme activities, water evaporation, gas exchange and decreased nutrient loss, which likely prevented the pathogen invasion in shelf life of fruits (Tavallali & Moghadam, 2015).Moreover, AVG reduced the nutrient availability to the pathogen which in turn resulted in less incidence of decay in shelf life of apple fruits. These findings are in agreement with the results of Jobling *et al*., (2003), Amarante *et al*., (2005) and Yuan and Carbaugh, (2007). Furthermore, LPE maintaining the plasma membrane which led to retard the senescence of apple fruits (Farag *et al*., 2011). Also, LPE can retard polygalacturonase mediated fruit softening (Hong *et al*., 2008), reduce activity of phospholipase D (PLD; EC 3.1.4.4) and membrane leakiness (Ryu *et al*., 1997; Hong *et al*., 2009a).

CONCLUSION

From the results of the present experiment, it could be concluded that, preharvest foliar application with AVG at 300ppm alone or followed by lisophos at 400 ppm reduced preharvest fruit drop, fruit decay % and increased yield and fruit firmness. Thus, both treatment are recommended to obtain the best yield and to decrease fruit deterioration after harvest in order to prolong the handling season with acceptable fruit coloration

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تاثير بعض معاملات ما قبل الحصاد على تساقط الثمار والجودة وحياة الرف لثمار التفاح صنف الأنا

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أجريت هذه التجربة خلال موسمى ٢٠١٨ - ٢٠١٩ لدراسة تاثير بعض معاملات ما قبل الحصاد بكل منأمينو ايثوكسى فينيل جليسين، نفثالين اسيتك اسيد،الليزوفوسوحامض الكوماريك على تساقط الثمار قبل الحصاد وجودة الثمار وفترة حياة الثمار على الرف بعد الحصاد.سبعة معاملات تم رشها وكانت كالتالى:أمينو ايثوكسى فينيل جليسين بتركيز ٣٠٠ جزء فى المليون ، أمينو ايثوكسى فينيل جليسين ٣٠٠ جزء فى المليون متبوعا بالرش بحامض الكوماريك بتركيز ٥٠ مللى مولر أو الليزوفوس بتركيز ٤٠٠ جزء فى المليون ، نفثالين اسيتك اسيد بتركيز ٢٠ جزء فى المليون، نفثالين اسيتك اسيد بتركيز ٢٠ جزء فى المليون متبوعا بالرش بحامض الكوماريك بتركيز ٥٠ مللى مولر أو الليزوفوس بتركيز ٤٠٠ جزء فى المليون بالاضافة الى الرش بالماء فقط (الكنترول). واوضحت النتائج ان الرش بكل من أمينو ايثوكسى فينيل جليسين منفردا او متبوعا ب الليزوفوس ادى الى تقليل تساقط الثمار قبل الحصاد ولكن ادى الى زياده المحصول و صلابة الثمار ،الحموضة ،النشا وكلورفيل (أ، ب) خلال الموسمين.بينما وزن ،حجم وابعاد الثمار زادت عند المعاملة بكل من نفثالين اسيتك اسيد منفردا او متبوعا ب الليزوفوس عند المقارنة بباقى المعاملات.ايضا المعاملة ب نفثالين اسيتك اسيد متبوعا بحامض الكوماريكادت الى زيادة تساقط الثمار قبل الحصاد،السكريات الكلية الذائبة و السكريات الكلية ومحتوى القشرة من الانثوسيانين خلال الموسمين بينما قللت صلاية الثمار فى كلا الموسمين. فيما يتعلق بفترة حياة الثمرة على الرف كل معاملات أمينو ايثوكسى فينيل جليسينأدت الى تقليل نسبة الفقد فى الصلابة والوزن وأعقان الثمار وايضا قللت من السكريات الصلبة الذائبة ومحتوى القشرة من الانثوسيانين عند المقارنة بباقى المعاملات. لذا فان الرش الورقى قبل الحصاد أمينو ايثوكسى فينيل جليسين بتركيز ٣٠٠ جزء فى المليون منفردا أو متبوعا ب الليزوفوس بتركيز ٤٠٠ جزء فى المليون قلل نسبه التساقط و قلل اعفان الثمار ولكن أدى الى زيادة المحصول و صلابه الثمار و بناءا عليه يمكن التوصيه بكلتا المعاملتين للحصول على اعلي محصول واطالة فترة حياة الثمرة على الرف مع تلوين مقبول للثمرة