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Effects of Aminoethoxyvinylglycine (AVG) and Naphthalene acetic acid (NAA) on Pre-harvest Fruit Drop and Quality of Washington navel orange

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ABSTRACT

The present study was conducted in 2017 and 2018 seasons in order to study the effects of Aminoethoxyvinylglycine (AVG at100.200 and 300mg/L) and Naphthalene acetic acid (NAA at 20 mg/L) applied in February and August on pre-harvest fruit drop and Quality of Washington navel budded on sour orange cultivated in a commercial orchard located in Nobaria region Behera Governorate, Egypt. Using AVG delay harvest three weeks, as well as the obtained data showed that AVG and NAA treatments reduced pre-harvest fruit drop and increased yield , fruit weight and numbers , fruit firmness, peel thickness, fruit length fruit diameter and Juice volume compared to the control trees . In the meantime, significant enhancement in fruit chemical characteristics was obtained by spraying the different treatments in both seasons, the percentage of TSS, acidity and vitamin C Similarly, an increase in total and non-reducing sugars whereas a decrease in soluble solids/acid ratio and reducing sugars content. AVG at 300mg/L treatment gave the highest of all previous parameters compared with the other treatments. However, spraying NAA gave the lowest except that of fruit length and TSS /acid ratio, in both seasons**.** AVG (ReTain®) used in this study could be of great economic benefit to growers by reduce per-harvest drop increase yield, improve fruit physical and chemical parameters of fruit and retain fruit quality.

Keywords**:** Aminoethoxyvinylglycine (AVG), Naphthalene acetic acid (NAA), Pre-harvest, Fruit Drop, Fruit Quality, Washington navel orange.

Introduction

Washington navel orange (*Citrus sinensis* L. Osbeck) is the most widespread species in the genus citrus in Egypt. It occupies about 35 % of the whole cultured area of citrus, the cultivated area reached about 155037 feddans with total production of 1619929 tons per year. According to the last census, issued by Ministry of Agriculture, Egypt (2017). Furthermore, fruit drop depend on the defect of auxins concentration at the separation layer, and the enzymes activity that transform insoluble pectin into a soluble form (Abd El-Ghany, 2005)

The problem of fruit drop is a big issue influence by the genes related with abscission zone formation (MdPG2 and MdEG1). Fruit drop is the separation of a fruit from the pedicel of a branch of tree or a plant, produced by the creation of a abscission layer of cells on the fruit stem owing to a series of physiological and biochemical events (Khandake *et al.,* 2016). The cruelty of pre-harvest drop is associated to several orchard and climatic influences such as pollination and fertilization (low magnesium (Mg), high potassium (K), and high boron (B)), soil fertility and nutrient status, growing season temperature (high temperature problem is likely related with a limitation in carbohydrate supply as too many of the good leaves are cut off leaving older less useful leaves. If leaf-fruit ratio become below 20: 1 then drop will be increased), water availability, heavy raining before fruit harvesting, and insect infestation or disease severity (heavy plagues of mites, leaf miners, and other insects or diseases led to the leaf damage that significantly reduce the photosynthate produced by the leaves this led to carbohydrate limitation supply to the fruits and result in increased pre-harvest drop). However, if substantial insect or mite damage is combined with high temperature or low Mg or drought stress the combine effects of each stress can increase the severity of pre-harvest drop. The Conditions help Ethylene synthesis that enhances the creation of enzymes that break down the cell walls and the complex sugars that hold cell walls composed in the abscission zone of the stem. When

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these glue-like materials break down, they leave the fruit related only by the vascular strands, which are easily broken.

Using growth regulators to rise fruit set and fruit size is very important in agriculture today because of their ability to improve vegetative growth, fruit set percentage, fruit quality and yield .Numerous growth regulators have been used to decrease drop rates. Naphthalene acetic acid (NAA) is one of those growth regulators and it has been used to control pre-harvest drops for about half century (Gardner *et al.,* 1939). Although a lot of researchers stated significant influences of NAA in regulating pre-harvest drops (Marini *et. al.,* 1993),(Curry, 2006), others reported that this substance has been either ineffective or inconsistent in controlling pre-harvest fruit drops depending on cultivars and climate issues (Byers ,1998; Yildiz *et al.,* 2012). Lately, Taiz and Zieger, (2008) indicated that 1-aminocyclopropane-1-carboxylic acid (ACC) turns into the ethylene in aerobic situations. As well as the creation of ACC is a biosynthetic step that restrains ethylene production in the tissues of the plants. Ethylene accelerates make softer fruit in citrus due to cell membranes disintegrating in order to make them leakier (Rath and Prentice, 2004; Ladaniya, 2007). Amino ethoxy vinyl glycine (AVG) is a growth regulator that prevents ACC-synthase activity (Yu and Yang, 1979).Amino ethoxy vinyl glycine (AVG) is commercially used to lessen fruit drop as a pre-harvest application (Greene, 2006). Commercially sold as ReTain®; It is a harmless organic product to environment and human (Öztürk *et al.,* 2012).Non-climacteric cultivars are incapable to produce a large quantity of ethylene, but that ethylene response in ‘Kinnow’ mandarin is similar as in climacteric types however very small amounts of ethylene were enough to gradually enhance fruit softening in mandarin (Tavallali and Moghadam, 2015**)**.

AVG has been used as an alternate to NAA to avoid pre-harvest drops in apples. It was reported that AVG delayed fruit ripening by impeding ethylene synthesis and is more active than NAA in controlling pre-harvest drops (Schupp and Greene, 2004; Dal Cin *et al.,* 2008). Although AVG was proved to be an effective compound to control pre-harvest drops in apples, response of different cultivars can significantly vary. Greene, (2006) revealed that low AVG doses should be used in cultivars with low ethylene production such as “Gala”. AVG was also used to decrease the pre-harvest fruit drop, improve the fruit quality and protect the fruit firmness (Bangerth, 1978; Bramlage *et. al.,* 1980; Greene and Schupp, 2004; Greene, 2005; Yuan and Carbaugh, 2007). Manipulate size, shape and color development (Drake *et. al.,* 2002), (Wang and Dilley, 2001), (Willams, 1980) and regulating the vegetative growth and control the flowering (Bangerth, 1978).

Retain acts by directing ethylene biosynthesis and thus the genes related with fruit abscission (MdPG2) and fruit softening (MdPG1) Retain blocks the production of ethylene caused by NAA and switches the fruit softening genes (MdPG1) in the fruit flesh. AVG is used in citrus production with a number of purposes including decreasing fruit drop and enriched ripening control. Ethylene stimulates the manufacture of enzymes (cellulose and polyglacturonase) that break down the glue that holds cell walls together in the abscission, zone of the stem, the cell walls, leaving the fruits connected to the tree by only the vascular strands, which are easily broken. Auxin lessens mature fruit by inhibiting ethylene-enhanced expression of the cellulase gene and creation of cellulase (Tucker *et. al.,* 1988; Zur and Goren, 1977). Cellulase is an essential hydrolytic enzyme involved in cell wall degradation and subsequent loosening or abscission of fruit. AVG is an analog of rhizobiotoxine, the root-nodule bacterium *Rhizobium japonicam* of soybean creates this phytotoxin. This phytotoxin competitively prevents the change of S-adenosylmethionine (SAM) to 1-aminocyclopropane-1-carboxylic acid (ACC) in the synthesis of ethylene (Byers, 1998). The inhibitory influence on ethylene biosynthesis and resulting suppression of ethylene production by AVG in various plant tissues is reported. AVG have the ability to decrease respiration ratio, cell wall softening enzyme activities (Eduardo and Kader, 2007; Win *et al.,* 2006).

The present study was therefore, undertaken to study the effects of application of AVG and NAA on pre-harvest fruit drop, yield and fruit quality of Washington navel orange grown in Nobaria region.

Material and Method

This study was carried out during the seasons of 2017, 2018 on Washington navel orange (*Citrus sinensis* L. Osbeck) cultivated in a commercial orchard located in Nobaria region Behera Governorate, Egypt. Trees were about 15 years old, spaced at 5x5 meters aparts, budded on sour orange rootstock (*C. aurantium* L.) .Sixty trees were chosen for the present study almost uniform in vigor and apparently healthy and subjected to the normal cultural practices. The experiment was arranged in a complete randomized block design with 5 treatments where each treatment had three replicates with four tree per each (5 x 3 x 4). Each tree was received 10 L of the applied solution plus 5cm per liter of tween 20 to avoid surface tension except those of control treatment which were sprayed with water only.

The treatments were designated as;

1- Control (tap water),
2- AVG (Retain; Valent Bio Sciences Corp., Libertyville, Ill.) at100mg/L
3- AVG at 200mg/L
4- AVG at 300mg/L
5- NAA at 20 mg/L

Total of two times with handgun sprayer. All treatments were applied on two equal doses in February and August during the two seasons of the study. Four secondary branches of four sides for each treated tree were randomly chosen labeled and calculated initial fruit set % at full bloom stage and total number of fruits after fruit set (developed fruitlets) in both seasons 2017 and 2018respectively, using the following equitation:

$$1 \text{ - Initial fruit set \%} = \frac{\text{Fruit set numbers after petal fall}}{\text{Total flowers number}} \times 100$$

$$2 \text{ - Final fruit set \%} = \frac{\text{Fruits number at end of June}}{\text{Total flowers number}} \times 100$$

Pre-harvest drop:

During the seasons the following parameters were carried out after June drop (at the mid of June) the number of remaining fruits was counted to estimate June drop The June drop percentage was calculated by using the following equitation.

$$3\text{-June drop \%} = \frac{\text{Initial fruit set - final fruit set}}{\text{Initial fruit set}} \times 100$$

$$4 \text{ - Total fruit drop \%} = \frac{\text{Fruit set number after petal fall - Number of final fruits}}{\text{Fruits set number after petal fall}} \times 100$$

5 – Pre-harvest Drop = Total fruit drop - June drop

Fruit sampling

After three weeks of commercial harvest date (when fruit coloring reached about 75% for AVG treated trees) in February, a sample of 15 fruit was randomly collected from each replicate in order to determine the effect of the different treatments on fruit quality characteristics at harvest date.

Yield and fruit quality parameters: Yield per tree expressed in weight (kg) was recorded at harvesting date. Fruit yield increment or reduction percentage is compared with the control was calculated by the following equation:

$$\text{Fruit yield increment or reduction \%} = \frac{\text{Fruit yield (kg)/treatment - Fruit yield (kg)/ control}}{\text{Fruit yield (kg)/ control}} \times 100$$

Fruit weight and numbers were calculated .Fruit shape index (length and diameter) were measured .Fruit firmness was measured with Effegl, Pentrometer (11.1 mm diameter prop, Effegl , Alfonsing, Italy and expressed as Lb/inch2).Peel thickness (mm) in each individual fruit was measured by using a digital vernier caliper. Juice volume was calculated and recorded. Also the percentage of total soluble solids (TSS %) was determined with a hand refractometer according to (A.O.A.C., 2000). Acidity% as citric acid according to A.O.A.C., (2000) and vitamin C was calculated asmg ascorbic acid /100 ml juice according to Horwitz, (1972).Soluble solids/acid ratio was calculated by the percentage of TSS on acidity to be used as a criterion for maturity determination .In addition, total and reducing sugars content (%) was determined according to Malik and (Singh,1980). The non-reducing sugars were calculated by the difference between total sugars and reducing sugars.

Statistical analysis.

Finally, all data obtained were statistically analyzed according to (Snedecor and Cochran ,1990) using the SAS version program (SAS, 2000).

Results and Discussion

Pre-harvest Drop:

The data in Table (1) showed that the pre- harvest drop, AVG at 300mg/L treatment gave significantly the lowest pre- harvest drop in both seasons whereas control treatment led significantly to the highest. AVG at 200mg/L treatment caused a significant decrease in pre- harvest drop than other treatments. As well as plants treated with AVG at 100mg/L scored significantly lower pre-harvest drop when compared with those treated with NAA at 20 mg/L.

These results are contact with previous researches in apple cultivars by (Greene *et al.,* 1987),(Amarante *et al.,* 2002) ,(Stover *et al.,* 2003), (Greene and Schupp, 2004), (Silverman *et. al.,* 2004),(Wargo *et al.,* (2004), (Argenta *et al.,* 2006), (Green, 2006),(Yuan and Carbaugh,2007), (Yildiz *et al.,* 2012) and (Öztürk *et al.,* 2015). They revealed that AVG applications significantly reduced accumulative drop rates compared to control and NAA application. Fruit drops of NAA-treated trees were similar to untreated trees. AVG was greater than NAA as a drop control and agent also, NAA was not as AVG in its effect of preventing pre-harvest drops.

Moreover, (Bregoli *et al*., 2002) on, nectarine, (Kim *et. al*., 2004) on 'Mibaekdo' peach trees and (Kang et al., 2007) on Angelino' Plum revealed that AVG treatments reduced fruit drop until harvest time compared to control. This may be due to AVG controlled pre-harvest drops in apples by preventing internal ethylene synthesis. Also, (Ozkan *et al.,* 2016) on apple stated that AVG treatments reduced pre-harvest drop by fifty percent comparatively to control.

On the other hand (Dussi *et al.,* 2002) found that pre-harvest application of AVG on Bartlett pear trees did not regulate pre-harvest fruit drop. Many of these variations in fruit growth and development are responsible of developing signals in which ethylene may not play a role. (Clayton *et al.,* 2000), (Kondo *et al.,* 1999, 2006), (Kondo and Seto, 2004),(Kondo and Takano, 2000) , (Murayama *et al.,* 2006) and (Yuan and Carbaugh, 2007) illustrated that exogenous ethylene and treatments that effect ethylene production in fruit devoted to the tree such as auxins or wounding induce fruit softening. In addition, (Kendrick and Chang, 2008) indicated that ethylene response occurs in plants by a cascade of events in which ethylene receptor proteins interrelate with ethylene and initiate the signaling process. As well as (Chen *et al.,* 2007) and (Kevany *et al.,* 2007) reported that the ethylene receptor proteins negatively regulate the ethylene response and are degraded, at least some of them, by ethylene exposure. Further, ethylene is the well-known trigger in abscission (Brown, 1997) that decreases auxins transport from the leaf blade to the petiole and encourages the synthesis of enzymes which in charge of the degrading of fruit abscission zone (Yuan and Carbaugh, 2007). Found that using chemicals to prevent ethylene biosynthesis would be valuable to decrease fruit drop. Accordingly, the positive effect of the sprayed growth regulators on lessening fruit drop.

Yield:

With regard to the yield, the data in Table (1) showed that in both seasons AVG at 300 mg/L treatment gave significantly the highest yield whereas control treatment led to the lowest. Significant differences found among AVG treatments and higher concentration gave best results than the lowest .NAA treatment led to a significant increase in yield as compared to control treatment. AVG treatments were superior comparatively to NAA and control. Yield increment refer to reducing fruit drop and increasing fruit weight and number and by AVG treatments The results of the current study support to those literature findings by Rath and Prentice, (2004). They reported that harvest delay shifted the ReTain-treated fruit to larger fruit size categories, giving a 12.3% increase in yield compared to the untreated fruit. Also, (Batjer *et al.,* 1957) concluded that AVG does not increase fruit size but larger fruit may be harvested on AVG treated trees because harvest will be delayed longer than on non-treated trees, as fruit size increase 1% per day. In addition,(Green and Schupp, 2004) illustrated that in most instance delaying harvest 2 to 3 weeks resulted in an increase in fruit size 15%-20% .the increase in size moves fruit from one size category to a larger one that is selling at higher price.

The increase in yield than control:

The data concerning the increase in yield than control revealed that AVG at 300mg/L gave significantly the highest increase in yield than control percentage in both seasons. As well as AVG at 200mg/L treatment caused a significant increment in the increase in yield than control percentage than other treatments. Also, AVG at 100mg/L treatment significantly increased yield than control percentage when compared with NAA at 20mg/L.

Fruit weight:

Concerning fruit weight Table (1), plants treated with AVG at higher concentration had significantly the highest fruit weight. However, lower concentration were also more effective than both NAA and control in both seasons .The findings on fruit weights in our study are similar to those of (Kim *et al.,* 2004), (Rath *et al.,* 2004), (Rath and Prentice ,2004) , (Amarante *et al.,* 2005) , (McGlasson *et al.,* 2005), (Yuan and Carbaugh ,2007) ,(Çetinbaş and Koyuncu ,2011) and (Öztürk *et al.,* 2012).They concluded that AVG significantly increased fruit weight. Also, (Noppakoonwong *et al.,* 2005) indicated that AVG application of 125 ppm on Tropic Beauty' peach variety increased the fruit size by 10% . According to (Butar *et al.,* 2013) the weight of fruits increased by AVG treatment 35%.

On the other hand, (Amarante *et al.,* 2002) stated that AVG at 250 mgL-1 inhibited fruit growth in Gala and(Ozkan *et al.,* 2016) revealed that low dose of AVG (150 mgL-1) did not affect fruit weight and high doses (300 and 600 mg L^{-1}) reduced fruit weight. Our previous results are confirmed by (Amarante *et al.,* 2001) who indicated that increasing fruit weight could be due to delay ripening and senescence and maintain cell integrity which may reduce water loss, or due to their effect on reduction of respiration rate as ethylene related change. AVG action by inhibiting ethylene evolution and decrease fruit respiration which resulted in good weight .Numerous research studies demonstrated that weight loss was associated with respiration processes and evaporation of water from the fruit. Also, increase fruit weight due to a protective role on fruit peel integrity and softening which reduced water evaporation, gas exchange and decreased nutrient loss. AVG coincided with their influence in increasing fruit volume. In this respect, (Martin ,1981) reported that larger fruits are stronger 'sinks' and remain on the tree without dropping on the contrary with smaller ones which are considered weaker 'sinks 'and drop preferentially. In addition, fruit weight increased with AVG treatment because the harvest will be delay longer than non-treated ones.

Table 1: Effect of AVG and NAA on pre-harvest drop, yield, Increase % in yield than control, fruit weight and fruit numbers of Washington navel orange.

Treatments	Pre-harvest Drop		Yield (kg)		% Increase in yield than control		Fruit weight (g)		Fruit numbers	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Control	25.37a	24.91a	58.71e	64.76e	0e	0e	209.74e	212.85e	279.9e	304.8e
AVG 100 mg/L	18.15c	16.88c	87.2c	94.29c	48.53c	45.6c	222.85c	225.57c	391.3c	418.6c
AVG 200 mg/L	15.78d	14.65d	100.88b	111,05b	71.83b	71.48b	224.42b	227.75b	449.5b	487.6b
AVG 300 mg/L	13.74e	11.48e	118.08a	122.11a	101.12a	88.56a	228.5a	230.13a	516.75a	530.6a
NAA 20 mg/L	18.44b	19.61b	83.04d	82.85d	41.44d	27.93d	215.69d	218.77d	385d	378.7d
LSD 0.05	0.025	0.021	0.416	0.031	0.029	0.0.043	0.129	0.127	1.9	1.03

Fruit numbers:

With regard to fruit numbers, AVG at the higher concentration gave significantly the highest fruit numbers. However, the lower concentration were also more effective than both NAA and control in both seasons .Increasing fruit numbers related to the reducing of fruit drop .The maximum number of fruits per tree with AVG might be attributed to less dropping of fruits, as the application of AVG made up the deficit of endogenous auxin, which prevented formation of abscission layer perhaps through the inhibition of enzymatic action at higher temperature. The findings of present study are in conformation with the results of (Greenberg *et al.,* 2006).

Fruit length:

As for fruit length in Table (2), AVG and NAA treatments caused a significant increase in fruit length as compared with control. Also, AVG at 300 mg/L gave significantly the largest fruit length .Significant differences were found between other treatments. These results are along with (McGlasson *et al.,* 2005) who illustrated that the AVG treated fruits were bigger than the fruits of the control group . Also, Butar *et al.,* (2013) indicated that AVG applications increased the fruit sizes in comparison with the control. In addition , (Greene and Schupp, 2004) reported that AVG treatment delayed harvest 2to3 weeks and this results in an increase in fruit size of 15% to 20%. Also, (Öztürk *et al.,* 2012) found that the effect of AVG treatments on the length was statistictically increased. As well as The AVG application on 'Tropic Beauty' peach variety increased the fruit size by 10% according to (Noppakoonwong *et al.,* 2005).The results of the current study also, agreed with those literature findings by (Stern *et al.,* 2007) they reported that treatments of NAA stimulated cell expansion in the fruit mesocarp, which caused an enhancement in fruit volume.

On the other hand, (Williams, 1980) reported that high doses of AVG reduced fruit size at harvest of apples.

Fruit diameter:

As for fruit diameter in Table (2), AVG and NAA treatments caused a significant increase in fruit diameter as compared with control. Also, AVGat300 mg/L gave significantly the largest fruit diameter. AVG 200 mg/L led to significant increase in fruit diameter when compared with AVG at100 mg/L and NAA at 20 mg/L treatments .Similar results were observed by various researchers for different fruit species, (Greene, 2006) revealed that AVG significantly increased fruit diameter of apple . Also, (Greene and Schupp ,2004) showed that fruit diameter in McIntosh apple significantly and linearly increased with increasing AVG concentrations .In addition, (McGlasson *et al.,* 2005) found that the fruits of nectarin were bigger and heavier than the fruits of the control group. Moreover The AVG application on 'Tropic Beauty' peach variety increased the fruit size by 10% according to (Noppakoonwong *et al.,* 2005). As well as (Tabatabaeefar and Rajabipour, 2005) who reported that the average width was70.0 mm for Red Delicious and Golden Delicious. Also, (Öztürk *et al.,* 2012) reported that the dimensions were higher as AVG doses increased and the width linearly increased .In addition , (Butar *et al.,* 2013) used AVG and illustrated that the diameters of the fruits expanded by 8.4%.Whereas (Williams ,1980) reported that high doses of AVG reduced fruit size at harvest of apples.

Fruit firmness:

As for fruit firmness, the data in Table (2) showed that fruits of plants treated with AVG at higher concentration had significantly the highest fruit firmness. However, lower concentration were also more effective than both NAA and control in both seasons. Similar results were observed by various researchers for different fruit species , (Hayama *et al.,* 2008) reported that fruit firmness is a quality parameter straight related to shelf life and fruit quality which was powerfully maintained by AVG in both climacteric and even non-climacteric fruits. Also, (Dekazos, 1979) indicated that firmness was slightly increased in fruit from branches treated with AVG. Moreover, (Palou and Crisosto, 2003) on apricot, (Valdés *et al.,* 2009) on apricot, (Mu˜noz-Robredoa *et al.,* 2012) on apricot, (Byers , 1998) on apple and (Garner *et al.,* 2001) on peach and (Tarabih, 2014) on pear revealed that AVG significantly slowed the softening rate and delay ripening of apricot, peaches, nectarines and pears. As well as (Layne *et al.,* 2002) ,(Whale *et al.,* 2008) and(Salas *et al.,* 2011) on nectarine,(McGlasson *et al.,* 2005)on peach,(Cetinbas *et al.,* 2012)on pears , (Andreotti *et al.,*2004) and (D'Aquino *et al.,* 2010)on plum ,(Jobling *et al.,* 2003) and (Öztürk *et al.,* 2012)on apples indicated that AVG maintain fruit firmer .In addition ,(Singh *et al.,* 2003) reported positive effects of AVG on fruit firmness in stone fruits and (Green, 2005) illustrated that AVG slowed the loss of flesh firmness and decrease internal ethylene concentration. (Rath *et al.,* 2004) also reported that application AVG to 'Tatura 204', 'Golden enhanced fruit firmness by 7-58% compared to control fruits. In addition, (Fallahi, 2007) on apple stated that AVG maintained firmness more than control .As well as (Yuan and Carbaugh, 2007) reported that NAA encouraged fruit ripening, reduced flesh firmness in 'Golden Supreme' and 'Golden Delicious apples. Also, (Çetinbaş and Koyuncu, 2011) found that all AVG concentrations gave higher fruit firmness values than control. Fruits treated with AVG are firmer (35-70 %) than those of control groups in 'Monroe' peach variety. Moreover, (Öztürk *et al.,* 2012) reported that fruit flesh firmness is an vital quality and ripening criteria for apple fruit. AVG provided significant influences in preservation of flesh firmness of 'Braeburn' apples and flesh firmness of AVG-treated fruits was higher than the control .In addition ,(Yildiz *et al.,* 2012) on apple indicated significant differences in flesh firmness between AVG concentrations whereas NAA spray did not cause a significant decrease in flesh firmness relative to control treatment at all dates while (Butar *et al.,* 2013)on nactarin found that the fruit firmness increased between 2.56% and 11.92% with AVG applications comparatively to the control fruits. As well as ,(Öztürk *et al.,* 2015) on apple revealed that flesh firmness were proved to be higher in AVG treatments than control treatment while firmness of NAA-treated fruits were found to be lower than control fruits.

In this respect, (Tavallali and Moghadam ,2015) reported that non-climacteric cultivars are unable to produce a large amount of ethylene, but that ethylene response in 'Kinnow' mandarin is the same as in climacteric types, also they indicated that very low amounts of ethylene were enough to slow fruit softening enhancement in mandarin. In addition , (Eduardo and Kader, 2007) and (Win *et al.,* 2006) revealed that fruit firmness is the most essential effective factor and AVG have the ability to reduce respiration rate, activities of cell wall softening enzyme and fruit firmness retention.

Peel thickness:

Regarding peel thickness Table (2), AVG at300 mg treatment gave significantly higher fruit peel thickness as compared with control in both seasons. Also, plants treated with AVG at 300 mg/L treatment had significantly higher fruit peel thickness than those treated with NAA at 20mg/L in the first season .Moreover ,AVG 200 mg/L led to significant increase in fruit peel thickness as compared with control in the first season. The results of the current study was supported by (Öztürk *et al.,* 2012) literature findings who indicated that ,the effect of AVG treatments on thickness, was statistictically significant as well as, (Öztürk *et al.,* 2012) who found that thickness linearly increased by AVG treatment. Also, (Tabatabaeefar and Rajabipour, 2005) reported that the average fruit thickness 67.0 mm for Red Delicious and Golden Delicious.

Table 2: Effect of AVG and NAA on fruit length, fruit diameter, fruit firmness, peel thickness and juice volume of Washington navel orange.

Treatments	**Fruit length(cm)**		**Fruit diameter(cm)**		**Fruit firmness 1b/inch^2**		**Peel thickness (cm)**		**Juice volume(mL^3)**	
	2017	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
Control	5.82e	6.3e	6e	6.08d	8.86e	8.81e	0.4c	0.45b	87.9e	89.96e
AVG 100 mg/L	6.22d	6.75d	6.47d	6.59c	9.83c	10.2c	0.43abc	0.48ab	103.38c	106.77c
AVG 200 mg/L	6.67c	7.13c	7.11b	7.24b	10.15b	10.39b	0.45ab	0.5ab	108b	111.1b
AVG 300 mg/L	7.04a	7.64a	7.6a	7.75a	10.59a	11.18a	0.47a	0.52a	116.9a	120.6a
NAA 20 mg/L	6.68b	7.23b	6.89c	7.1b	9.74d	9.59d	0.42bc	0.469ab	93.7d	96.89d
LSD 0.05	0.021	0.062	0.08	0.199	0.018	0.039	0.0412	0.054	0.947	0.228

Fruit juice volume:

As for fruit juice Table (2) , plants treated with AVG at 300 mg/L treatment contained significantly the highest fruit juice volume in both seasons whereas those with control treatment had significantly the lowest . AVG at 200mg/L treatment caused a significant increase in fruit juice volume than AVG at 100mg and NAA at 20 mg/L treatments . As well as plants treated with AVG at 100 mg scored significantly higher fruit juice volume when compared with those treated with NAA at 20 mg/L. These results are supported by (Rokaya *et al.,* 2016) who reported that the increase in juice percentage of mandarin may be described by the fact that hormones play a regulating role in the mobilization of metabolites within a plant and it is well known fact that developing fruits are extremely active metabolic “sinks” which mobilize metabolites and direct their flow from vegetative structure.

Total soluble solids contents (TSS %) :

Total soluble solids percentage is considered to be an important parameter of quality of citrus fruits to know the time of harvesting. The data in Table (3) indicated that fruits of plants treated with AVG at higher concentration had significantly the highest fruit total soluble solids content. However, lower concentration were also more effective than both NAA and control in both seasons as well as no significant differences were found between control and NAA at 20 mg/L in the first season. These results are in line with those found by (Singh *et al.,* 2003) on ‘O’Henry’ and ‘Summerset’ types, (Greene, 2006) on apple, (Rath and Prentice, 2004) on ‘Arctic Snow’ peach variety, (Butar *et al.,* 2013) on nactarin , Tavallali and Moghadam, (2015) on Kinnow mandarin and (Radwa Satour,2019) on apricot. They illustrated that AVG applications increased the soluble solid contents of the fruits. Also, (Ingel *et al.,* 2001) on Nagpuri mandarin indicated that soluble solids were elevated in fruits treated with ReTain alone at the first harvest.

In contrary on apple cultivars (Byers 1998) ,(Wargo *et al.,* 2004),(Greene, 2005),(Schupp and Greene, 2004) and (Ozkan *et al.,* 2016) and (Tarabih ,2014) pear found that fruit treated with AVG had a lower percent of TSS.

On the other hand (Dong *et al.,* 2002), (Palou and Crisosto, 2003) ,(Valdés *et al.,* 2009 and Mu˜noz-Robredoa *et al.,* 2012) on apricot, (Wargo *et al.,* 2004) , (Yuan and Carbaugh , 2007) and (Öztürk *et al.,* 2012) on apple , (Morales-Payan *et al.,* 2009) on‘Red Lady’ papaya and (Candir *et al.,* .(2017) and (Zulferiyenni *et al.,* 2016) on banana they reported that AVG treatments did not affect TSS. (Yildiz *et al.,* 2012) on apple found that the difference between control and NAA treatment was not significant for soluble solids.

Previous studies revealed that ethylene inhibitors, by preventive fruit respiration metabolism and fungal growth, thereby delay the declines of nutritional components such as soluble solids (Hagenmaier, 2005). The increase in TSS by AVG application may possibly be due to the breakdown of complex organic metabolites into simple molecules or due to hydrolysis of starch into sugars (Wills *et al.,* 1998).

Asgharia and Aghdam, 2010) and (Ezzat *et al.,* 2014) illustrated that AVG effects maintaining cell wall integrity and delay degradation. Cell walls contain large amounts of polysaccharides, mainly pectins and cellulose. The activation of cell wall degrading enzymes during the ripening progress solubilize the cell wall components which leading to a significant increase in SSC content.

Acidity:

The data in Table (3) showed acidity percentage, AVG at 300mg/L treatment caused significantly the highest fruit juice acidity in both seasons whereas control and NAA at 20 mg/L treatments gave significantly the lowest . AVG at 200mg/L treatment led to a significant increase in fruit juice acidity than AVG at 100mg/L treatment ..These results are in agreement with those found by(Singh *et al.,* 2003) on O’Henry’ and ‘Summerset peach, (Tarabih ,2014) on pear, (Tavallali and Moghadam, 2015) on Kinnow mandarin ,(Ozkan *et al.,* 2016) on apple and (Radwa Satour, 2019) on apricot they reported that AVG showed an increase in titra Table acidity. As well as, (Salas *et al.,* 2011) indicated that using AVG for instance preserving acidity in apple. On contrasting, (Dong *et al.,* 2002), (Palou and Crisosto, ,2003), (Valdés *et al.,* 2009)in apricot and(Mu˜noz - Robredoa *et al.,* 2012) on peach, (Morales-Payan *et al.,* 2009) on chill peach, (Berry and Argent, 2004) on Red Lady’ papaya, (Argenta *et al.,* 2006) on apple and (Zulferiyenni *et al.,* 2016) on‘ Cavendish’ banana, they mentioned that AVG treatments did not affect total acidity. (Yildiz *et al.,* 2012) indicated that NAA and AVG treatments did not cause any significant change in titraTable acidity relative to control. As well as, (Butar *et al.,* 2013) on nactarin reported that the effects of AVG on total acidity was not significant.

In this respect (Brahmachari *et al.,* 1997) on Guava trees and (Hikal, 2013) on Washington navel orange found that TSS/acid ratio of fruits was improved while fruit total acidity was reduced.

Previous studies revealed that ethylene inhibitors, causes limiting fruit respiration metabolism and fungal growth, thereby delaying the declines of nutritional components such as titraTable acidity (Hagenmaier, 2005). AVG maintained higher acidity probably due to delay in ripening process.

(Sigal-Escalada, 2006) reported that the AVG treatments aided in better retention and cumulative of acidity as compared to control, which might be due to the positive role of treatments in delaying the ripening process and decreasing respiration of fruits. Sugars and organic acids donate to fruit taste and are used as respiratory substrates. (Tucker , 1993) revealed that total acidity mainly reflects the abundance of citric and ascorbic acids, the most conspicuous organic acids in citrus .Citric acid is a major respiratory substrate and can fall by 50% during the ripening of a fruit.

TSS/acid ratio:

The results for TSS/Acidity indicated that AVG at 300mg/L treatment gave significantly the lowest TSS/Acidity ratio, whereas ,NAA at 20 mg/L treatments led to a significant increase in TSS/Acidity ratio than control in the first season and other treatments in the second seasons. Also, AVG at 100mg/L treatment significantly decreased TSS/Acidity ratio when compared with AVG 200mg/L. These obtained results are in contract with that of (Brahmachari *et al.,* 1997) on Guava trees and (Hikal, 2013) on Washington navel orange who found that TSS/acid ratio of fruits was improved while fruit total acidity was reduced.

VC:

Concerning Vc in Table (3), AVG at 300mg/L treatment gave significantly the most Vc content in both seasons whereas control treatment led significantly to the lowest . Significant differences were found between other treatments. Previous studies revealed that ethylene inhibitors, by preventive fruit respiration metabolism and fungal growth, thereby delaying the declines of nutritional components such as, ascorbic acid (Hagenmaier, 2005).Also, ethylene might be playing a detrimental role through its involvement in oxidative injury to the loss of vitamin C content of fruit (Singh and Pal, 2008). Moreover, (Blankenship and Dole, 2003), (Watkins, 2006) and (Win *et al.,* 2017) indicated that AVG suppressed the ethylene synthesis accordingly, prevent VC loses. (Tavallali and Moghadam, 2015) on Kinnow' mandarin indicated that AVG treatments significantly increased vitamin C. (Radwa Satour, 2019) on apricot found that AVG treatments with both concentrations maintained higher VC content in both seasons. The reduction of ascorbate is often considered as a symptom of fruit senescence (Borracino *et al.,* 1994).

Table 3: Effect of AVG and NAA on TSS , Acidity, TSS/A and VC of Washington navel orange.

Treatments	TSS%		Acidity%		TSS/A		VC(mg./100juice)	
	2017	2018	2017	2018	2017	2018	2017	2018
Control	11.94d	12.32e	0.979d	0.999d	12.2ab	12.33b	39.46e	42.59e
AVG 100 mg/L	12.39c	12.71c	1.03c	1.07c	12.03b	11.88c	42.68c	46.33c
AVG 200 mg/L	12.86b	13.26b	1.12b	1.17b	11.48c	11.33d	46.94b	50.45b
AVG 300 mg/L	13.44a	13.78a	1.18a	1.25a	11.39e	11.02e	51a	55.36a
NAA 20 mg/L	12.1d	12.42d	0.977d	0.976d	12.39a	12.73a	41.55d	45.78d
LSD0.05	0.177	0. 1	0.023	0.027	0.293	0.252	0.21	0.093

Total sugar:

Concerning total sugar content ,the data in Table(4) indicated that AVG at 300mg/L treatment gave significantly the highest total sugar content in first season.as well as in second season AVG at 200 and 300mg/L treatments led to a significant increase in total sugar content than other treatments, whereas fruit of plants treated with NAA at 20mg/L had significantly the lowest . In the second season, AVG at 200mg/L treatment caused a significant increase in total sugar content than AVG at 100mg/Land NAA 20mg/L treatments. Also, AVG at 100mg/L treatment significantly increased total sugar content when compared with control treatment .In the current study, the total sugar content was between 6.44%-7.97 %. These results are in line with those obtained by (Colarıč *et al.,* 2004) who reported that total sugar and sucrose content varied from 6.15 to 9.37% and from 4.61 to 7.01% in peach and nectarine cultivars, respectively. Sugars and organic acids donate to fruit taste and are used as respiratory substrates (Tucker, 1993). Respiration is the oxidation breakdown of complex molecules such as starch ,sugars and organic acids, (Kader and Saltveit , 2003).The results of the current study support to those literature findings by (Çetinbaş and Koyuncu,2011) on Monroe' Peaches who revealed that statistically significant interaction effects between concentrations and application times on the fruit total sugar in both seasons between concentrations and application times on the fruit total sugar , in second year they found that AVG fruits had the highest sugar content and total sugar content was between 5.06-11.50%.

On the other hand , (Radwa Satour ,2019) on apricot found that there were no significant differences on total sugars of fruit flesh between control and AVG treatments in both seasons.

Reduced sugar:

The data regarding reducing sugars showed that plants with control treatment had significant higher reduced sugar content than those with other treatments except AVG at 100mg/L whereas that of NAA treatment had the lowest. Also ,AVG at 100 and 200mg/L gave significantly higher reduced sugar content than AVG at 300mg/L.As well as reduced sugar content in plants treated with AVG at 100 was significantly higher than AVG at 200mg/L. Similar results were observed by various researchers for different fruit species,(Çetinbaş and Koyuncu, 2011) on Monroe' Peaches who reported that there were statistically significant interaction effects between concentrations and application times on reduction of sugar in both years. Also,(Radwa Satour ,2019) applied AVG on apricot and revealed that the highest significant reducing sugars percentage was found with the control in both seasons .The increase in reducing sugars can be attributed to sugars accumulation as a result of the metabolism of polysaccharaides as repining progress. (Çetinbaş and Koyuncu, 2011) reported a significant interaction effects between concentrations and application times on reduced sugar content and the reduction in sugar content was between 2.52-9.50%.

Non Reduced sugar:

The data in Table (4) discuss non reduced sugar content and appeared that plants treated with AVG at higher concentration had significantly the highest non reduced sugar content. However, lower concentration were also more effective than both NAA and control in both seasons. These results are along with those found by (Çetinbaş and Koyuncu ,2011) found statistical significance for the interaction effects between concentrations and application times on sucrose content and the sucrose content was between 1.94-5.00%.(Ozkaya *et al.,* 2014). They reported statistical significance for the interaction effects between concentrations and application times on sucrose contents. As well as (Radwa Satour (2019) on apricot revealed that control has significantly lower content of non-reducing sugars percentage among treatments when compared with AVG treatments.

In this respect (Chapman and Horvat ,1990) reported that the sucrose content of the 'Monroe' peach was around 7-8% at harvest and (Fallahi,2007) on apple revealed that AVG reduced starch hydrolysis more than control.

Table 4: Effect of AVG and NAA on Total sugar**,** reduced sugar and non-reduced sugar of Washington navel orange.

Treatments	Total sugar (%)		Non Reduced sugar (%)		Reduced sugar (%)	
	2017	2018	2017	2018	2017	2018
Control	7.02c	7.83b	3.04d	3.35d	3.98a	4.48a
AVG 100 mg/L	7.14b	7.77c	3.17c	3.43c	3.97a	4.34b
AVG 200 mg/L	7.19b	7.97a	3.38b	3.69b	3.81b	4.28c
AVG 300 mg/L	7.26a	7.96a	3.49a	3.91a	3.77c	4.05d
NAA 20 mg/L	6.44d	6.71d	2.87e	2.91e	3.57d	3.8e
LSD0.05	0.013	0.057	0.021	0.016	0.0103	0.017

In economic study of yield production the main economic criteria were cost of each substance(AVG and NAA) that used under study(L.E / fed.), cost of labor and spraying motor (L.E / fed.), averages yield (ton / fed) for two seasons (2017& 2018), price of yield over control (L.E) and net profit (L.E / fed.) for each treatment. Results are given in Table (5).

Other expenses such as the costs of supervision and royalties were not taken into consideration in this study .In more details unite price of AVG was (5.33 L.E / k.gm.) and NAA was (1.5 L.E / k.gm.) taking into account of both AVG and NAA were sprayed at two times under study. The study also revealed that the cost of labor that were used per treatment as well as the spraying motor and thus the total costs were calculated. Also averages yield (ton /fed.) for the first and second seasons and yield over control were calculated and finally the net profit (L.E/ fed.) for yield over control was determine .From this economic study it could be noticed that, application of AVG at300mg/L. was the best for giving the highest net profit / fed. (23331.6 LE) followed in descending order by using of AVG at 200 mg/L (18235.9 L.E), AVG at100mg/L (12584.4 L.E) and NAA at 20mg/L (10702.7 L.E) and so on as shown in Table (5).

Table 5: Economic study for using AVG and NAA applications on yield of Washington Navel orange trees.

Treatments	Total Q .of Each Trea./ fed.	Unit Price (L.E	Cost of each Trea./fed. (L.E)	NO. Labor/ year	Labor & S.M. fees (L.E)	Labor & S.M. Cost (L.E	Total cost trea./ fed. (L.E	Average yield for two seas. Ton/ fed.	Yield over control Ton/fed.	Yield over control Price (L.E.	Net Profit/ Fed. (L.E)E)
Control								10495.8			
AVG 100 mg/L	396g	5.33	2110.7	2	50	100	2210.7	15427.5	4931.7	14795.1	12584.4
AVG 200 mg/L	792g	5.33	4221.4	2	50	100	4321.4	18014.9	7519.1	22557.3	18235.9
AVG 300 mg/L	1188g	5.33	6332	2	50	100	6432	20417	9921.2	29763.6	23331.6
NAA 20 mg/L	12g	1.5	14.4	2	50	100	114.4	14101.5	3605.7	10817.1	10702.7

Where: (S.M.) refers to Spraying Motor., two times.

Conclusion

Obtained results of AVG: ReTain® used in this study could be of great economic benefit to growers by reduce per-harvest drop, increase yield, improve fruit physical and chemical parameters of fruit and retain fruit quality.

Reference

Abd El-Ghany, N.A., 2005. Fruit drop. Agricultural J. Ministry of Agriculture, Egypt (In Arabic), 60(3): 21-22.

Ali, M.M., 2000. Flowering, fruit setting and drop in deciduous fruit trees. Agric. J., Ministry of Agriculture, Egypt (In Arabic), 55(4): 42-43.

Amarante, C., N.H. Banks and S. Ganesh, 2001. Relationship between character of skin cover of coated pears and permeance to water vapour and gases. PostharBiol Tech 21(3):291–301.

Amarante, C.V.T., A. Simioni, C.A. Megguer and L.B.E. Blum. 2002. Effect of aminoethoxyvinilglycine (AVG) on preharvest fruit drop and maturity of apples. Rev. Bras. Frutic. 24:661-664.

Amarante C.V.T, A.M.F. Drehmer, F .Souza and P. Francescatto, 2005 .Pre-harvest spraying with gibberellic acid (GA_3) and aminoethoxyvinilglycine (AVG) delays fruit maturity and reduces fruit losses on peaches. Revista Brasileirade Fruticultura 27: 1–5.

A.O.A.C., 2000.Official Methods of Analysis of the Association of Official Analytical Chemists.17th ed. Washington, DC, USA.pp 578.

Argenta, L.C., M.J. Vieira, J.G. Krammes, J.L. Petri and C. Basso, 2006. AVG and 1-MCP effects on maturity and quality of apple fruit at harvest and after storage. Acta Hort. 727:495-503.

Andreotti, c.; A.M. Bregoli and G. Costa, 2004. Pre and postharvest aminoethoxyvinylglycine (AVG) application affects maturity and storage of pear fruit. Europ. J. Hort.Sci., 69(4):147-152.

Asgharia, M. and M.S. Aghdam, 2010.Impact of salicylic acid on post-harvest physiology of horticultural crops. Trends in Food Science – Technol. 21.502–509.

Bangerth, F., 1978. The effect of a substituted amino acid on ethylene biosynthesis, respiration, ripening and preharvest drop of apple fruits. J. Amer. Soc. Hort. Sci., 103:401–404.

Batjer, L, H. D. Billingsley, M. N. Westwood and B. L. Rogers, 1957.Predicting harvest size of apples at different times during growing season. *Proceeding of the American Society for Horticultural Science,* 70: 46–47.

Berry, A.D. and S.A.S. Argent, 2004. Pre- and postharvest application of RiTain® to 'Red Lady' papaya fruit: Effect on harvest maturity, ripening and quality. Proc. Fla. State Hort. Soc. 117:389-391.

Blankenship, S.M. and J.M. Dole, 2003. 1- Methylcyclopropene: a review. Postharv. Biol. Technol. 28:1-25.

Borracino, G, L. Mastropasqua; S.DeLeonardis and S. Dipierro, 1994. The role of ascorbic acid system in delaying the senescence of oat (*Avena sativa* L.) leaf segments. J. Plant Physiol., 144:161-166.

Brahmachari, V., N. Kumar and R. Kumar, 1997. Effect of foliar feeding of Calcium, Potassium and Growth substances on yield and quality of guava (*Psidium guajava* L.). *Haryana J. hort. Sci*. 26 (3-4), 169-173.

Bramlage, W.J., D.W. Greene, W.R. Autio and J.M. Mclaughlin, 1980. Effect of aminoethoxyvinylglycine on internal ethylene concentration and storage of apples. J. Amer. Soc. Hort. Sci., 105:847-851.

Bregoli, A.M., S. Scaramagli, G. Costa, E. Sabatini, V. Ziosi, S. Biondi, and P. Torrigiani, 2002. Peach (*Prunus persica*) fruit ripening aminoethoxyvinylglycine (avg) and exogenous polyamines affect ethylene emission and flesh frimness. Physiologia Plantarum, 114:472-481.

Brown, K.M., 1997. Ethylene and plant responses to nutritional stress. Physiol. Plant, 100: 567-576.

Butar, S., M. Çetinbaş and I. Eren, 2013. The Effects Of Aminoethoxyvinylglycine (AVG) On Fruit Quality Of 'EksiBir Cv.' Nectarine. Ege Üniversites I Ziraat Fakültesi Dergisi, ÖzelSayısı Volume II., 371-375.

Byers, R.E. 1998.Effects of aminoethoxyvinylglycine (AVG) on preharvest fruit drop and maturity of 'Delicious' apples. J. Tree Fruit Prod. 2:53-75.

Candir, E., A. Candir and F. Sen, 2017. Effects of aminoethoxyvinylglycine treatment by vacuum infiltration method on postharvest storage and shelf life of tomato fruit. Postharvest Biolo. and Technol. 125: 13–25.

Chapman. G .W and R. J. Horvat, 1990. Changes in nonvolatile acids, sugars, pectin, and sugar composition of pectin during (cv. Monreo) maturation. Journal of Agricultural and Food Chemistry, 38(2): 383-387.

Chen, Y.F., S.N. Shakeel, J. Bowers, X.C. Zhao, N. Etheridge, and G.E. Schaller, 2007. Ligandinduced degradation of the ethylene receptor ETR2 through a proteosome-dependent pathway in Arabidopsis. J. Biol. Chem. 282:24752–24758.

Clayton, M., W.V. Biasi, S.M. Southwick and E.J. Mitcham, 2000, "ReTain™ Affects Maturity and Ripening of `Bartlett' Pear. HortScience, vol. 35 no. 7, 1294-1299.

Çetinbaş, M., S. Butar, C.E. Onursal and M. A. Koyuncu, 2012. The effects of pre-harvest ReTain [aminoethoxyvinylglycine (AVG)] application on quality change of 'Monroe' peach during normal and controlled atmosphere storage. ScientiaHorticulturae, 147: 1-7.

Çetinbaş, M and F. Koyuncu , 2011. Effects of Aminoethoxyvinylglycine on Harvest Time and Fruit Quality of 'Monroe' Peaches, Tarım Bilimleri Dergisi – Journal of Agricultural Sciences 17 :177-189.

Colaric, M., F. Stampar and M. Hudina, 2004. Contents of sugars and oraganic acids in the cultivars of peach (*Prunus persica* L.) and nectarine (*Prunus persica* var. nucipersica Schneid.). Acta Agriculturae Slovenica, 83(1): 53-61.

Curry, E.A., 2006. Changes in ripening physiology of 'Delicious' and 'Fuji' apples treated preharvest with NAA. Acta Hort., 727: 481-488.

Dal Cin, V., M. Danesin, A. Botton, A. Boschetti, A. Dorigoni and A. Ramina, 2008. Ethylene and preharvest drop: The effect of AVG and NAA on fruit abscission in apple (*Malus domestica* Borkh.). Plant Growth Regul., 56:317-325.

D'Aquino, S., M. Schirra, M.G. Molinu, M. Tedde and A. Palma, 2010. Pre-harvest aminoethoxyvinylglicine treatments reduce internal browning and prolong the Shelf-life of early ripening pears. Sci. Hortic., 125: 353-360.

Dekazos, E. D., 1979. Effects of aminoethoxyvinyl-glycine (AVG) on bloom delay, fruit maturity of 'Tifblue' and 'Woodard' rabbiteye blueberries. Proc. Fla. State Hort. Soc., 92: 248.

Dong, L.; Susan Lurie and H.W. Zhou, 2002. Effect of 1-methylcyclopropene on ripening of 'Canino' apricotsand 'Royal Zee' plums. Postharvest Biol. Technol., 24:135-145.

Drake, S. R., D. C. Elfving and T. A. Eisele, 2002. Harvesting maturity and storage affect quality of 'Cripps Pink' (Pink Lady®) apples. HortTechnology, 12: 388–391.

Dussi, M.C., D. Sosa and G.S. Calvo, 2002. Effects of Retain™ on fruit maturity and fruit set of pear cultivars Williams and Packham's Triumph. Acta Hort. 596:767-771.

Eduardo, V.B and A.A. Kader, 2007. Effect of 1-methylecyclopropen on softening of fresh cut kiwifruit, mango and persimmon slices. Posthar Biol Tech., 43(2): 238-244.

Ezzat A., Z. Szabó and A. K. Ammar, 2014.The role of some elicitors in inducing chilling stress resistance in apricot fruit. Acta Agraria Debreceniensis, The J. of Agric. Sci.,59: 27-32.

Fallahi, E., 2007. Influence of 1-aminoethoxyvinylglycine hydrochloride and α-naphthalene acetic acid on fruit retention, quality, evolved ethylene, and respiration in apples. Int. J. Plant Prod. 1:53-61.

Gardner. F.E, P.C .Marta and L.P. Batjer, 1939.Spraying with plant growth substances for control of the pre-harvest drop of apples. J. Am. Soc. Hortic. Sci. 37: 415-428.

Garner, D., C.H. Crisosto and E. Otieza, 2001. Controlled atmosphere storage and aminoethoxyvinylglycine postharvest dip delay post cold storage softening of 'Snow King' peach. Hort. Technol., 11: 598-601.

Greenberg. J, I. Kaplan, M. Fainzack, Y. Egozi and B. Giladi, 2006.Effects of auxins sprays on yield, fruit size, fruit splitting and the incidence of creasing of Nova Mandarin. Acta Horticulturae, 727

Greene, D.W, K. Kaminsky and J. Sincuk, 1987. An evaluation of stop drop materials in 1986. Proc. New England Fruit Meeting 93:74-78.

Greene, D.W. and J.R. Schupp, 2004. Effect of aminoethoxyvinylglycine (AVG) on preharvest drop, fruit quality, and maturation of 'McIntosh' apple. II. Effect of timing and concentration relationship and spray volume. Hort Science 39:1036-1041.

Greene, D.W., 2005. Time of aminoethoxyvinylglycine application influences preharvest drop and fruit quality of 'McIntosh' apples. Hort Science 40:2056-2060.

Greene, D.W, 2006. An update on preharvest drop control of apples with aminoethoxyvinylglycine (ReTain). Acta Hort. 727:311-319.

Hagenmaier. R.D., 2005. A comparison of ethane ethylene and CO2 peel permeance for fruit with different coatings. Posthar Biol Tech., 37(1):56- 64.

Hayama, H., M. Tatsukiand and Y. Nakamura, 2008. Combined treatment of aminoe-thoxyvinylglycine (AVG) and 1-methylcyclopropene (1-MCP) reduces melting-flesh peach fruit softening. Postharvest Biology and Technology 50, 228–230.

Hikal, A.R., 2013. Effect of Foliar Spray with Gibberellic Acid and Amcotone on Fruit Set, Dropping, Component Yield and Fruit Quality of Washington Navel Orange Trees. J. PlantProduction, Mansoura Univ., 4 (6), 1015 - 1034.

Horwitz, W., 1972. Official Methods of Analysis Associationof Official Analytical Chemists11thed. Washington, D.C.

Ingle, H.V., N.G. Rathod and D.R. Patil, 2001. Effect of growth regulators and mulching on yieldand quality of Nagpuri mandarin. Ann. Plant Phy., 15(1): 85-88.

Jobling, J., R. Pradhan, S.C. Morris, L. Mitchell and A.C. Rath, 2003. The effect of ReTain plant growth regulator [aminoethoxyvinylglycine (AVG)] on the postharvest storage life of 'Tegan Blue' plums. Aust. J. Exp. Agric. 43, 515–518.

Kader, A.A. and E.M. Saltveit, 2003. Respiration and gas exchange. In: Bartzans Brecht (eds.) Postharvest physiology and pathology of vegeTables.pp.7-29.CRC Press. New York.

Khandake .M.M., N.S.Idris, S. Z.Ismail, A. Majrashi, A. Alebedi and N. Mat ,2016. Causes and Prevention of Fruit Drop of *Syzygium Samarangense* (Wax Apple): A Review. Advances in Environmental Biology, 10(11) November 2016, Pages: 112-123

Kang I, J. Byun, H. Kweon, M. Kim, S .Kwon, M. Park, D.H. Lee, C .Choi and D.G .Choi, 2007. Effects of aminoethoxyvinylglycine on preharvest drop, fruit colour, and quality of 'Tsugaru' Apples. Hortic. Envir. Biotechnol., 48: 159-164.

Kendrick, M.D. and C. Chang. 2008. Ethylene signaling: New levels of complexity and regulation. Curr.Opin. Plant Biol., 11:1–7.

Kevany, B.M., D.M. Tieman, M.G. Taylor, V.D. Cin, and H.J. Klee, 2007. Ethylene receptor degradation controls the timing of ripening in tomato fruit. Plant J. 51:458–467.

Kim. I.S, C.D.Choi, H.J .Lee and J.K .Byun, 2004. Effect of Amino ethoxy vinyl glycine on pre-harvest drop, fruit quality of Mibaekdo peaches. Acta Horticulturae 653: 173–178.

Kondo, S., K. Inoue and T. Manabe, 1999. Cell wall metabolism of pear fruit on the tree after 2, 4-DP treatment. J. Hort. Sci. Biotechnol., 74:614–617.

Kondo, S. and H. Seto, 2004. Changes of jasmonic acid during ripening in pear fruit and interactions between jasmonic acid and abscissic acid. Acta Hort. 636:537–543.

Kondo, S. and Y. Takano, 2000. Cell wall metabolism and induction of ripening capacity in ‘La France’ pears as influenced by 2,4-DP. Journal of the American Society for Horticultural Science. American Society for Horticultural Science, 125(2):242-247 .

Krezdorn, A.H., 1965. Fruit setting problems in citrus Proc. *Carib. Reg.* Amer. Soc. Hort. Sci., 9, 85-92.

Ladaniya, M., 2007. Citrus Fruit: Biology, Technology and Evaluation. Academic Press.p: 558.

Layne,D.R., J. Zhengwang and J.W. Rushing, 2002 .The influence of reflective film and ReTain on red skin coloration and maturity of "Gala"apples.HortTecnology12,640-645.

Malik, C.P. and M.B. Singh, 1980. Plant Enzymology and Histo Enzymology. Kalyani Publishers, New Delhi, 1980, p. 286.

Marini, R.P., R.E. Byers and D.L. Sowers, 1993. Repeated application of NAA control preharvest drop of ‘Delicious’ apples. J. Hort. Sci.68:247-253.

Martin, G.C., 1981. Physiology of fruit set and growth. In: Prune Orchard anagement. DANR Special Publication 3269 (ed. D.E. Ramos), pp: 55-60.

McGlasson, W.B., A.C. Rath, and L. Legendre, 2005. Preharvest application of aminoethoxyvinylglycine (AVG) modifies harvest maturity and cool storage life of ‘Arctic Snow’ nectarines. Postharvest Biol. Technol. 36, 93–102.

Ministry of Agriculture and Land Reclamation, 2017. Economic affairs sector, Bulletin of the agricultural statistics Part (2) Summer& Neil crops.

Morales-Payan, J.P.; M.d.C. Libran and E. Hernandez, 2009. Effects of aminoethoxyvinyl glycine (AVG) in tow low- chill peach cultivars. Proceedings of the Caribbean. Food Crops Soc., 45: 188-194.

Mu˜noz –Robredoa, P., P. Rubiob, R. Infanteb, R. Campos-Vargasc, D. Manríqueza, M. González-Agüeroa and B.G. Defilippia, 2012. Ethylene biosynthesis in apricot: Identification of a ripening-related aminocyclopropane-1-carboxylic acid synthase (ACS) gene. J. Agri. Food Chem., 57: 5809-5815.

Murayama, H., D. Sekine, Y. Yamauchi, M. Gao, W. Mitsuhashi, and T. Toyomasu. 2006. Effect of girdling above the abscission zone of fruit on ‘Bartlett’ pear ripening on the tree. J. Expt. Bot. 57:3679–3686.

Noppakoonwong, U., P. Sripinta, A.C. Rath, A.P. George, and R.J. Nissen, 2005. Effect of Retain and potassium chloride on peach fruit quality ın the subtropical highlands of Thailand. Production technologies for low-chill temperate fruits. Reports From The Second International Workshop, Chiang Mai, Thailand, Vol: 61, pp.117-120.

Ozkaya, O., S. Çomlekcioglu and H. Demircioglu, 2014. Assessment of the Potential of 1-Methylcyclopropene treatments to maintain fruit quality of the common fig (*Ficus carica* L cv. ‘Bursa Siyahi’) during refrigerated storage. Not. Bot. Hort. Agro., 42: 516-522.

Ozkan.Y, B. Öztürk and K. Yıldız, 2016. Effect of Aminoethoxyvinilglycine and Naohthalene Acetic Acid On Ethylene Biosynthesis, Pre-harvest fruit drop and fruit quality of apples. Pak. J. Agri. Sci., 53(4), 893-900; 2016

Öztürk, K.B., E. Kucuke, S. Karaman and Y. Özkan, 2012. The effects of cold storage and aminoethoxyvinylglycine (AVG) on bioactive compounds of plum fruit (*Prunus salicina* L. cv. ‘Black Amber’). Postharvest Biol. Technol., 72: 35-41.

Öztürk, B., K. Yıldız, Y. Ozkan and K. Kilic, 2015. Effect of Amino ethoxy vinilglycine (AVG) on Pre-harvest fruit drop and fruit quality of Braeburn’ apples. Bangladesh J. Bot., 44(2): 299-307, 2015 (June).

Palou, L. and C.H. Crisosto. 2003. Postharvest treatments to reduce the harmful effects of ethylene on apricots. Acta Hort., 599: 31-38.

Radwa Satour, F.S., 2019.Effect of Postharvest Aminoethoxyvinylglycine, 1-Methylcyclopropene and Jasmonic Acid Treatments on Storability and Quality Maintenance of Apricot Fruit cv. "Canino" M.Sc. Thesis Agriculture (Pomology) ,Faculty of Agriculture, Alexandria University.

Rath, A.C. and A.J. Prentice, 2004. Yield increase and higher flesh firmness of ‘Arctic Snow’ nectaries both at harvest in Australia and after export to Taiwan following pre-harvest application of retain plant growth regulator (aminoethoxyvinylglycine, AVG). Australian Journal of Experimental Agriculture, 44:343-351.

Rath, A.C., J.M. Wargo and S. Mills, 2004. Aminoethoxyvinylglycine (AVG) applications to commercial blocks of ‘Tatura 204’, ‘Golden Queen’ and ‘Taylor Queen’ peaches delays fruit maturity and increases fruit size and quality. Acta Horticulturae, 653:167-171.

Robinson, T., 2015 The Physiology of Apple Pre-harvest Fruit Drop Dept. of Horticulture NY SAES, Cornell University Geneva, NY 14456

Rokaya, P.R., D.R. Baral, D.M. Gautam, A.K. Shrestha and K.P. Paudyal, 2016. Effect of Pre-Harvest Application of Gibberellic Acid on Fruit Quality and Shelf Life of Mandarin (Citrus reticulate Blanco). American Journal of Plant Sciences, 7 (7): 1033-1039.

Salas, N.A., F.J. Molina-Corral, G.A. González-Aguilar, A. Otero, D.R. Sepulveda and G.I. Olivas, 2011. Volatile production by ‘Golden Delicious’ apples is affected by pre-harvest application of aminoethoxyvinylglycine, 130(2): 436-444.

SAS, 2000. Statistical analyses software version 2000. Raleigh. NC. U. S. A.

Schafer, G, O.C. Koller and I.A. Sartori, 1999. Fruit retention of Monte Parnaso Navel oranges in relation to application of 2,4-D, gibberellic acid and shoot ringing. *Ciencia Rural,* 29 (4): 639-644.

Schupp, J.R. and D.W. Greene, 2004. Effect of amino ethoxy vinyl glycine (AVG) on preharvest drop, fruit quality, and maturation of ‘McIntosh’ apples. I. oncentration and timing of dilute application of AVG. HortScience 39:1030-1035.

Sigal-Escalada, V., 2006. Interactions of AVG, MCP and heat treatment on apple fruit ripening and quality after harvest and cold storage. Doctoral Dissertations. University of Kentucky, USA, 448p.

Singh, Z., K. Kennison, and V. Agrez, 2003. Regulation of fruit frimness, maturity and quality of later maturing cultivars of peach with preharvest application of ReTain. Acta Horticulture, 628:277-283.

Singh, S.P. and R.K. Pal, 2008. Response of climactric-type guava (*Psidium guajava* L.) to postharvest treatment with 1-MCP.PostharvestBiol.Technol.,47:307-314.

Snedecor, G. and W.G. Cochran, 1990. Statistical methods 7th Ed.The lowa state.Univ. press.Arnes. Lowa. USA. pp: 593.

Silverman, F.P., P.D. Petracek, M.R. Noll and P. Warrior, 2004. Amino ethoxy vinyl glicine effects on late-season apple fruit maturation. Plant Growth Regul., 43:153-161.

Stern, R.A., M. Flaishman, and R. Ben-Arie, 2007. Effect of synthetic auxins on fruit size of five cultivars of Japanese plum (*Prunus saliciana* Lindl.). Scientia Horticulturae, 112, 304-309.

Stover, E.D, M.J. Fargione, C.B. Watkins and K.A. Iungerman, 2003. Harvest management of Marshall ‘McIntosh’ apples: Effects of AVG, NAA, ethephon, and summer pruning on pre-harvest drop and fruit quality. Hortscience38: 1093-1099.

Tabatabaeefar, A. and A. Rajabipour, 2005. Modeling the mass of apples by geometrical attributes. Scientia Horticulturae*,* 105: 373–382.

Tarabih, M.E., 2014. Improving storability of Lecont pear fruit using aminoethoxyvinylglycine (AVG) and oxalic acid (OA) under cold storage. Asian J. crop sci., 6: 320-333.

Tavallali, V. and M.M. Moghadam, 2015. Postharvest application of AVG and 1-MCP enhance quality of ‘Kinnow' mandarin during cold storage. Int. J. Farm. Alli. Sci., 4: 526-535.

Taiz, L. And E. Zieger, 2008. BitkiFizyolojisi (Üçüncübaskıdançeviri; Çevirieditörü İsmail Türkan). Palme Yayıncılık 689 s.

Tucker, G.A., 1993. Introduction .In: Seymour, G.B, Taylor, J.E Tucker .G.A .(eds), Biochemistry of fruit ripining,PP1-51 Champman and Hall ,London.

Tucker, M.L., R. Sexton, E. del Campillo, and L.N. Lewis,1988. Bean abscission cellulose. Plant Physiol. 88:1257–1262.

Valdés, H., M. Pizarro; R. Campos-Vargas; R. Infante and B.G. Defilippi, 2009. Effect of ethylene inhibitors on quality attributes of apricot cv. Modesto and Patterson during storage. Chilean J. Agric. Res. 69: 134-144.

Wang, Z. and D. R. Dilley, 2001.Aminoethoxyvinylglycine, combined with ethephon, can enhance red color development without over-ripening apples. Hort Science,36: 328–331.

Wargo, J.M., I.A. Merwin and C.B. Watkins ,2004. Nitrogen fertilization, midsummer trunk girdling, and AVG treatments affect maturity and quality of 'Jonagold' apples. Hortscience 39: 493-500.

Watkins, C.B., 2006. The use of 1-methylcyclopropene (1-MCP) on fruits and vegeTables. Biotechnol Adv., 24:389-409.

Whale, S. K., Z. Singh, M.H. Behboudian, J. Janes and S.S. Dhaliwal, 2008. Fruit quality in 'Cripp's Pink' apple, especially colour, as affected by preharvest sprays of aminoethoxyvinylglycine and ethephon. ScientiaHorticulturae, 115: 342-351.

Wills, R., B. Mcglasson, D. Graham and D. Joyce, 1998. Postharvest an introduction to the physiology and handling of fruit and vegetables and ornamentals (4th Edn). Sydney 2052, Australia, University of New South Wales Press Ltd., 125-156.

Williams, M.W., 1980. Retention of fruit firmness and increase in vegetative growth and fruit set of apples with aminoethoxyvinylglycine. HorScience, 15:76-77.

Win, N.M., J. Yoo, S. Ryu, J. Lee, H. Jung, M. Choung,K. Park, Y. Cho; S. Kang and I. Kyu, 2017. Effects of harvest times with polyethylene (PE) film liner 1-methylcyclopropene (1-MCP) and aminoethoxyvinylglycine (AVG) treatments on fruit quality in' Sangjudungsi' persimmon during cold storage. Korean. J. Food Preserv., 24: 898-907.

Yu Y.B. and S.F. Yang, 1979. Auxin-induced ethylene production and its inhibition by aminoethoxyvinylglycine and cobalt ion. Plant Physiology, 64:1074-1077.

Yildiz K, B. Öztürk and Y .Ozkan, 2012. Effects of aminoethoxyvinylglycine (AVG) on preharvest fruit drop,fruit maturity, and quality of 'Red Chief' apple. Sci. Hortic.-Amsterdam 144: 121-124.

Yuan, R. and D.H. Carbaugh, 2007. Effects of NAA, AVG, and 1-MCP on ethylene biosynthesis, preharvest fruit drop, fruit maturity, and quality of 'Golden Delicious' apples. Hortscience, 42: 101-105.

Zulferiyenni, S.; E. Widodo and A. Putri, 2016. Effects of Aminoethoxyvinylglycine, Chitosan and storage temperatures on fruit shelf-life and qualities of „Cavendish" banana. 26th Int. Conference on Agri., Environ. Biol. Sci. (ICAEBS'16) Dec. 21-22, 2016 Kuala Lumpur (Malaysia).

Zur, A. and R. Goren, 1977. Reducing preharvest drop of 'Temple' orange fruits by 2,4-D—Role of cellulose in the calyx abscission zone. Sci. Hort. 7:237–248.