Butar, S., **Çetinbaş**, M., Eren, İ. 2013. The Effects Of Aminoethoxyvinylglycine (AVG) On Fruit Quality Of 'Eksi Bir Cv.' Nectarine. Ege Üniversitesi Ziraat Fakültesi Dergisi, Özel Sayısı Volume II., 371-375.

The Effects Of Aminoethoxyvinylglycine (AVG) On Fruit Quality Of 'Eksi Bir Cv.' Nectarine

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ABSTRACT

'Eksi Bir' nectarine cultivar is an early maturing variety mostly produced in Antalya region which is important for early fruit production in Turkey. This variety is the most important for the early market. ReTain (15% AVG) is a plant growth regulator used for prevention of pre-harvest fruit drop and for increasing fruit weight and firmness. The aim of this research was to determine the effects of pre-harvest AVG treatments on fruit quality of 'Eksi Bir' nectarine cultivar. For this purpose, 125 ppm of aminoethoxyinylglycine (AVG) was sprayed onto fruits and leaves around the fruits of 5-year-old nectarine (*Prunus persica var. nucipersica* Schneid. cv. Eksi Bir) trees at 1, 3 and 4 weeks before the predicted harvest date. Fruit length (mm), fruit width (mm), fruit weight (g), fruit firmness (N), kernel weight, length of fruit stalk, titratable acidity (%), soluble solid contents (%), pH (%), fruit colour (L*, a*, b*,C*, h*), ethylene production (µL/kg.h) and respiration rate (µL/kg.h) were determined at harvest time.

Key words: AVG (aminoethoxyinylglycine), 'Eksi Bir cv.' Nectarine, Fruit quality, Harvest time

INTRODUCTION

Aminoethoxyvinylglycine (AVG) is a known inhibitor of ACC synthase (ACS) activity (Yu and Yang, 1979) which converts S-adenosylmethionine (SAM), which is the major methyl group donor for numerous transmethylation reactions. 1-amino-cyclopropane-1-carboxylic (ACC), the immediate precursor of ethylene is the rate-limiting enzyme in ethylene biosynthesis (Bregoli et al., 2002). AVG is the active ingredient of a chemical (ReTain®) that in field trial was shown to reduce fruit abscission and to improve fruit quality (Byers, 1997). ReTain plant growth regulator, containing 15% w/w AVG, was registered in Australia in October 2001 for use in apples, peaches and nectarines (Rath and Prentice, 2004). Pre-harvest spraying with ReTain (15 % AVG) has been demonstrated to delay ripening and reduce pre-harvest drop of fruits in apples, peaches, nectarines and other climacteric fruits (Autio and Bramlage, 1982; Park et al., 1999; Bregoli et al., 2002). However, the effects of AVG depend on application concentration and time, cultivar and environmental conditions (Matoo et al., 1977; Kim et al. 2004). In a study conducted in a commercial orchard of 'Arctic Snow' nectarines, application of 125g AVG/ha 7 days before anticipated first harvest gave a 2.75 day harvest delay based on standard commercial maturity criteria. This harvest delay shifted the ReTain-treated fruit to larger fruit size categories, giving a 12.3% increase in yield compared to the untreated fruit (Rath and Prentice, 2004). Çetinbaş and Koyuncu (2011) also reported that application of AVG (100-150-200 ppm) to 'Monroe' peach resulted in a reduction of 7-21-30 days of harvest time and increased fruit weight by 3-47%, fruit firmness by 35-73% compared to control fruits.

This study was conducted in Antalya, one of the most important early fruit production centers for nectarines in Turkey. 'Eksi Bir' nectarine variety is the most important one for early marketing and for the export market. Therefore, this study examined the effects of pre-harvest application of ReTain on different application times on harvest delay, fruit size, fruit quality, ethylene production, and respiration rate of 'Eksi Bir' nectarine.

MATERIAL AND METHODS

Trees (6-year-old) of *Prunus persica var. nucipersica* Schneid cv. Eksi Bir, grafted on GF305 seedling rootstock and trained to a free open-vase, were selected for their size and fruit load uniformity. They were sprayed with ReTain (Valent BioSciences Corp., USA), a commercial product containing 15% (w/w) AVG. ReTain was applied as an aqueous solution, containing 0.05% (v/v) of a surfactant (Tween-20), at dose corresponding to 125 ppm onto fruits and leaves around the fruits until runoff. The spraying was performed with a hand pump sprayer at 7, 21 and 30 days before commercial harvest (DBH). Fruits were harvested at a commercial maturity stage when the ground colour changed from green to yellow-red at intervals of 3-4 days for yield and fruit assessment. The fruits picked at the harvest time were immediately transported to the post-harvest physiology laboratory. Fruits were harvested 3 times on 14 May (first harvest), 17 May (second harvest), 20 May (third harvest). The data used for analysis in this paper comes from the second harvest because the highest percentage of mature fruit picked was in the second harvest. The fruit weight, fruit colour (measured with a Minolta Chroma Meter CR-300 using the CIE L*, a*, b*, c*, h*), fruit firmness (using a Lloyd LF Plus Universal Test Machine), and soluble solids content (SSC) (using a digital Palette PR–32 Atago refractometer) were measured. The colour was measured on both sides of the fruit. Fruit firmness was tested at two points on the fruit surface with a plunger having 8 mm diameter tip. Titratable acidity (TA) was determined by using a digital burette (Digitrate Isolab 50 m*l*) through titration of 10 ml of diluted juice with 0.1 N NaOH up to pH 8.1, and the TA was expressed as malic acid. Ethylene production (µL/kg.h) and respiration rate (µL/kg.h) were determined in fruit placed in closed jars after keeping for 1 day at room temperature (20±1 °C) (1 kg of fruit was closed in each jar and the volume of each jar was 4 liters). The respiration rate was measured with a gas analyzer. The ethylene production rate was determined using gas chromatography with a flame ionization detector (Gunes et al., 2001). The experiment was set up according to the split plot experimental design with 3 replications with each replication composed of one tree. The differences between the mean of the groups was determined by Duncan multiple range test. All analyses were performed with SPSS software package v.16.0 for Windows by General Linear Model (GLM) univariate test.

RESULTS

Fruit maturity and harvest time

'Eksi Bir' nectarine fruits have been harvested sequentially. The fruit treated at 125 ppm, which matured during the same period, were harvested seven days before the estimated harvest time. The application of 125 ppm advanced the maturation and three days after the period and these fruits were harvested for the first time on the mentioned date. The fruits of the control group and 7 DBH AVG group constituted the group first harvested. The second harvest was performed immediately when the fruits of groups 21 and 30 DBH AVG were suitable for harvest. The third harvest of the trial was performed for all fruits on May 20. As a result, the control groups and 7 DBH AVG applications were harvested in three periods while 21 and 30 DBH AVG applications were harvested in two periods. Therefore; the application of AVG at 125 ppm dose 21 and 30 days before the harvest delayed the maturity and made the harvest period more compact.

Fruit size and firmness

The evaluation results of the effects of AVG applications on some fruit quality features are given in Table 1. The AVG applications increased the fruit sizes in comparison with the control groups and the increase has been statistically significant ($P<0.05$). The diameters of the fruits expanded by 8.4% and the weight of fruits increased by 35% particularly with 30 DBH AVG treatment. In addition to the important increase of fruit size, the AVG application was very effective when applied on the 30 and 21 days prior to the estimated harvest time. The effect of AVG applications on fruit firmness was statistically significant ($P<0.05$). The AVG application

30 DBH has the highest value (48.92 N) in terms of fruit firmness, followed respectively by 21 DBH (47.93 N) and 7 DBH (44.83 N).

Soluble Solids (SSC) and Titratable Acidity Contents and Ph

The effects of AVG applications on SSC and pH have been found statistically significant ($P<0.05$) but effect on TA was not significant (Table 2). The AVG applications increased the soluble solid contents of the fruits. The highest SSC (14.00%) was obtained with 30 DBH application where fruits had the lowest pH value (2.20).

Ethylene production and respiration rate

AVG applications reduced the production of ethylene and the respiration rate in comparison with the control group. The effects of the applications on the production of ethylene and the respiration rate have been statistically significant ($P<0.05$). The lowest ethylene production rate was 0.237 μL/kg.h at 30 DBH AVG application whereas the highest rate of the ethylene production (0.237 μL/kg.h) was obtained from the control group. The effects of AVG applications on respiration rate were parallel to ethylene production and the respiration rate of the control group was higher than that of the AVG applied groups.

Fruit colour

The effects of the AVG applications on fruit colour are indicated in Table 3. The effects of AVG applications on all colour values have been found statistically significant, except for a* which presents the red colour ($P<0.05$). The highest values were obtained from 21 DBH AVG application as L* (38.15), b* (23.90) and h* (35.88). The lowest values of L* (33.75), b* (18.57) and h* (29.40) were obtained from the control fruits.

DISCUSSION

The control groups and 7 DBH AVG applications were harvested three times during the 7-day harvest period, whereas 30 and 21 DBH AVG applications were harvested twice during the four-day harvest period. These results are important for reducing the harvest cost which has a big share in the production cost. Moreover, these applications delayed the harvest for 3 days and shortened the harvest period by 3 days. According to many researches performed on peaches and nectarines, the harvest time is delayed and the fractional harvest period shortens when the AVG are applied, which are parallel to our results (Ju et al., 1999; Sing et al., 2003; Rath and Prentice, 2004; McGlasson et al., 2005; Noppakoonwong et al., 2005). The AVG applications caused an apparent increase in the fruit weight. Such increases proved to be very important on the early nectarine fruit weight, and it was determined that the 30 and 21 DBH AVG applications were very effective on fruit weight. According to a research on "Arctic Snow", it has been reported that when AVG is applied as 125 ppm eight days before the estimated harvest time, the fruits were bigger and heavier than the fruits of the control group (McGlasson et al., 2005). The AVG application of 125 ppm was done 7 and 14 days before the estimated harvest time and it delayed the harvest of 'Tropic Beauty' peach variety for 7 days and increased the fruit size by 10% according to Noppakoonwong et al. (2005). The positive effects of AVG application on fruit firmness was also displayed in our study. The fruit firmness increased between 2.56% and 11.92% with AVG applications compared to that of the control fruits. There are many researches (Singh et al., 2003; Rath et al., 2004) about the positive effects of AVG on fruit firmness in stone fruits however in addition to this, Launder and Jerie (2000) pointed out that AVG application increased the fruit firmness between 12% and 60% in pome fruit approximately. Çetinbaş and Koyuncu (2011) found out that the firmness of fruits treated with AVG are firmer (35-70 %) than those of control groups in 'Monroe' peach variety under Eğirdir conditions in Turkey. Rath and Prentice (2004) emphasized that AVG application of 125 ppm increases the firmness, the weight and SSC in 'Arctic Snow' peach variety if applied 7 days before the estimated harvest time. In our study, the AVG applications increased SSC, as in other studies, and the highest

increase was observed in 30 DBH AVG application. Likewise, a study on peach varieties 'Q'Henry', 'Summerset', 'Zee Lady' and the 'Elegant Lady' has shown that AVG application increased SSC and TA in 'Q'Henry' and 'Summerset' peach varieties if applied 15, 10 and 5 days before the estimated harvest time. In our study, the effects of the AVG applications on color values were important on L*, b*, C* and h*, but not on value a*. L* refers to the brightness and darkness of the colour, and value b*, signifies the rise in yellow background colour but lower red blush when AVG is applied. The effects of AVG application on coloration were different in different studies. Singh et al. (2003) stated that the effects of AVG applications on pigmentation varies according to the varieties and they have no effects on 'O'Henry' and 'Summerset' peach varieties, but on 'Zee Lady' peach variety the red colour on a yellow background was lowered. This result shows parallelism with our study. In another study carried out on peach varieties 'Tatura 204', 'Golden Queen', and 'Taylor Queen' there were delays in coloration in AVG applied fruits but at harvest they have the same coloration as those of the control group (Rath et al., 2004). Fruit softening is known to be one of the ripening processes that are most sensitive to ethylene. Fruit softening in peaches and nectarines are correlated with an increase in ACC and ethylene production. AVG applied as a pre-harvest spray to peaches inhibits ethylene synthesis (Boller et al., 1979; Kim et al., 2004; Rath and Prentice, 2004). The ethylene production and the respiration rate decreased with the applications and the lowest ethylene production and respiration rate were measured on 30 DBH AVG treated fruit. Kim et al. (2004) stated that AVG lowered the amount of ethylene and the respiration rate of the 'Mibaekdo' peach variety and also the application dose affected in the same way as in the findings of Bregoli et al. (2002) for 'RedHaven' peach variety. In our study, the effect of the application time was significant on ethylene production and respiration rate. The ethylene production and the respiration rates were low in 30 and 21 DBH AVG applications; whereas the 7 DBH AVG treated fruit had similar figures with that of the fruits of the control group. Since there was no delay in the harvest time and the fruit quality (weight and firmness) lagged behind those of fruits treated with 30 and 21 DBH AVG, the performance of 7 DBH AVG application seems to be directly linked to its ethylene production. On this ground, it is very important that the AVG applications are used for preventing the fruits from producing ethylene long before its natural occurance. In the Yang cycle, the primary molecule of ethylene is amino-cyclopropane-1-carboxylic (ACC). It is already known that ACC turns into the ethylene in aerobic environments (Taiz and Zieger, 2008). This shows that the synthesis of ACC is a biosynthetic step that restrains ethylene production in the tissues of the plants.

CONCLUSION

With this study, especially the notable effects of the AVG applications of 21 and 30 DBH are proven in terms of harvest time and duration and the fruit quality features of 'Eksi Bir' nectarine variety. This effect is considered to have arisen since AVG application restrains the production of ethylene which maintains the flow between the fruit stalk and the fruit. Ethylene is the major element of maturity and the restraining of ethylene cause delay in the cycle between the acid and the sucrose. Likewise the delay of harvest and maturity of the fruits like peach, apple, pear, apricot, and plum results from the delay between AVG and the ethylene (Lurie et al., 1997; Taiz and Zieger, 2008). This study also showed that the most appropriate application time of AVG for 'Eksi Bir' variety is between 30 and 21 days before the estimated harvest time. The notable part of 'Eksi Bir' variety grown in Antalya, Turkey is its potential to export in the very early season. For this reason, the duration of the shelf life is spent during transportation. It is obvious that AVG applications increase the fruit firmness and it not only reduces the loss of quality during transportation but also extends the shelf life period. We think that these findings are also profitable for producers since they can create a market jointly due to the shortened harvest period of nectarines and peaches.

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TABLES

Table 1. The effect of AVG doses on some fruit characteristics of 'Eksi Bir' nectarine cultivar

Application	Fruit width (mm)	Fruit length (mm)	Fruit height (mm)	Fruit weight (g)	Firmness (N)
Control	54.07b	51.44c	53.07b	82.23b	43.71b
7 DBH	53.90b	53.34b	54.24b	84.64b	44.83b
21 DBH	54.00b	52.03bc	54.58b	96.29a	47.93a
30 DBH	58.61a	57.16a	59.79a	110.97a	48.92a

With each column. values followed by the same letter are not significantly different at $P < 0.05$ level according to Duncan's multiple range test.

Table 2. The effect of AVG on fruit chemical characteristics of 'Eksi Bir' nectarine cultivar

Application	SSC (%)	TA (%)	pH	Ethylene production (µL/kg.h)	Respiration rate (µL/kg.h)
Control	13.40b	0.12	2.24ab	0.237a	26.90a
7 DBH	13.70ab	0.13	2.26a	0.234a	24.59b
21 DBH	13.60b	0.12	2.23ab	0.151b	22.71c
30 DBH	14.00a	0.13	2.20b	0.100b	20.74d

With each column. values followed by the same letter are not significantly different at $P < 0.05$ level according to Duncan's multiple range test.

Table 3. The effect of AVG on colour characteristics of 'Eksi Bir' nectarine cultivar

Application	L*	a*	b*	C*	h*
Control	33.75b	33.96	18.57b	37.50b	29.40b
7 DBH	36.68ab	32.05	22.91a	40.96a	33.57a
21 DBH	38.15a	33.59	23.90a	40.52ab	35.88a
30 DBH	36.17ab	32.48	21.87ab	40.60ab	32.08ab

With each column. values followed by the same letter are not significantly different at $P < 0.05$ level according to Duncan's multiple range test.