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Aminoethoxyvinylglycine (AVG) Delays Maturation and Improves Fruit Size and Firmness of cv. '0900 Ziraat' Sweet Cherry

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Summary

This study was conducted to delay fruit ripening and enhance fruit quality (size and firmness) of cv. '0900 Ziraat' sweet cherry in Turkey. For this purpose, ReTain containing 15 % aminoethoxyinylglycine (AVG), was applied at various concentrations (0, 50, 100 or 150 mg L^{-1}) onto fruits and leaves around the fruits of 10-years-old cv. '0900 Ziraat' sweet cherry on 'Gisela 5' dwarf rootstock at the straw-yellow stage (about 30–35 days prior to the harvest). Fruit maturity was delayed about 4–6 days in AVG-applied (50 and 100 mg L^{-1}) fruits. Application of AVG increased the fruit size and fruit mass of cv '0900 Ziraat' sweet cherry. All AVG concentrations led to firmer fruit relative to the unsprayed control fruits. Effects of AVG concentrations on SSC were not significant. Application of AVG decreased the ethylene efflux from the cherry fruit. As a result, application of AVG at 50 or 100 mg L^{-1} concentrations at the straw-yellow stage for '0900 Ziraat' sweet cherry variety can be recommended in situations and countries, where this compound is officially approved.

Key words. AVG – ReTain – sweet cherry – '0900 Ziraat' – fruit quality – ripening

Introduction

Turkey is a country with a considerably high potential of sweet cherry production and has to make use of this potential to the utmost level. However, it is not possible to take advantage of this potential, unless an efficient and high quality sweet cherry production is achieved. Turkey, however, has severe yield and quality problems for sweet cherries as well as for other fruits. Sweet cherry is one of the two important fruits grown at Isparta in Turkey, which has a high fruit growing potential. Sweet cherry production shows a continuous annual increase in the Isparta region. Whereas the production was 5,158 t in 1990, this figure reached 17,419 t in 2003 and 21,885 t in 2010, which makes up about 7 % of Turkey's fruit production. Of the total amount of sweet cherries produced in the world, 241,223 t are exported. Turkey is the leading country in this sector with about 57,000 t of sweet cherry export (Fao 2010). In order to increase this available economic potential and to ensure its sustainability, modern growing methods should be widespread in addition to traditional cultural applications. In recent years, AVG (aminoethoxyinylglycine) is one of the chemicals used to increase fruit quality and especially fruit size and firmness. AVG is an inhibitor of ACC synthase (ACS) activity, which converts S-adenosylme-thionine (SAM), which is the major methyl group donor for numerous transmethylation reactions, to 1-amino-cyclopropane-1-carboxylic acid (ACC), the immediate precursor of ethylene (Yu and Yang 1979); it is the rate-limiting enzyme in ethylene biosynthesis (Kende 1993). AVG is the active ingredient of a new chemical (ReTain®), which reduced fruit abscission and to improved cherry fruit quality in a field trial in the USA (Byers 1997), but without registration/approval in Europe. Pre-harvest spraying with ReTain® in the USA, Italy and Korea delayed ripening and reduced pre-harvest drop of apples, pears, peaches, nectarines and other fruits (Autio and Bramlage 1982; Park et al. 1999; Bregoli et al. 2002; Andreotti et al. 2004). However, the effects of AVG depend on application concentration, time, cultivar and environmental conditions (Matoo et al. 1977; Kim et al. 2004). Kim et al. (2004) sprayed various concentrations (100, 150, 200 mg L^{-1}) of AVG onto cv. 'Mibaekdo' peach trees at 3 and 4 weeks before the commercial harvest. AVG greatly reduced the pre-harvest fruit drop rate in a concentration-dependent manner. AVG sprayed three weeks before commercial harvest date appeared to be more effective than four weeks before the commercial harvest. At harvest, the AVG-sprayed fruits had significantly larger fruit mass than control fruits; they also showed decreased ethylene production and respiration. Southwick et al. (2006) found that AVG applied to apricot prior harvest significantly increased fruit firmness. The sweet cherry rootstocks that have been used in the world and Turkey up until the recent years have been 'Mazzard' seedling and 'Idris'. These vigorous rootstocks, which

restrict heavy production, have recently been eliminated by dwarfing rootstocks. The dwarfing, early and efficient 'Gisela 5' rootstock, bred by the University of Gießen (Germany), appears as a fairly promising rootstock. However, the fruits of the cultivars grown on trees on this dwarf rootstock in Turkey are smaller and softer than those grown on Mazzard seedling, which in turn causes the fruits grown on 'Gisela 5' rootstock to lack important properties for export. Consequently, low quality sweet cherry (softer, poor coloration and variety in taste, low dry matter, small fruit etc.) cannot find a place in international markets because of its short shelf life and transportation resistance and due to the fact they are not in demand by customers. There are hundreds of cherry cultivars in Turkey. However, the cultivar that is known worldwide as the 'Turkish Cherry' and which is exported the most is '0900 Ziraat'. This cultivar makes up about 90 % of our export. The production of this quality cultivar that is intended for table use and fresh consumption is about 50–70 thousand tons. When all the sweet cherry cultivars grown in Turkey are considered, this may be a high amount. However, exportable production cherry amount is limited. Thus, the objective of using AVG applications on '0900 Ziraat' sweet cherry cultivar, which is an important export product is to increase quality and to contribute to both the producer and country economy by increasing the fruit size and firmness along with the positive properties of 'Gisela 5' rootstock. However, AVG as a plant growth regulator could be classified as a "hormone" in consumer-conscious European countries and hence be rejected by retailers in those countries.

Materials and Methods

Experiments were carried out at the Fruits Research Station of Eğirdir, Isparta, Turkey in 2010–2011. Uniform 10-years-old cv. '0900 Ziraat' sweet cherry trees on 'Gisela 5' dwarf rootstock, spaced at 5x3 m were used. Trees were trained to a Vogel central leader and pruned in late winter, and standard cultural practices had been used with the trees for several years. The experimental design was a randomized block, with 4 treatments and 3 replicates using a single tree for each treatment. ReTain® containing 15 % AVG, obtained from Valent BioSciences Corp., USA, was sprayed at concentrations of 0 (water + surfactant), 50, 100, or 150 mg L^{-1} AVG plus 1 % (v/v) Tween 20 as a surfactant onto fruit and leaves around the fruits until run-off. The back pump used for spraying and 6 liters water per tree. The applications were made when the fruits were at the straw-yellow stage (about 30–35 days prior to the harvest). The fruits picked at the harvest time were immediately transported to the post harvest physiology laboratory in ice containers. Fruits were harvested at a commercial stage of maturity when the red color. The measurement of 30 fruits per tree were determined using a digital caliper for fruit width (mm), fruit length (mm), peduncle length (mm), peduncle thickness (mm). Fruit, seed and peduncle weight (g) were determined by a digital scale sensitive to 0.01 g. The colour of the fruit was determined with a colorimeter (Minolta Chroma meter CR-100) using the L* a* b* scale. Fruit firmness (using a Lloyd LF Plus Universal Test Machine) was tested at two points on the fruit surface with a plunger of 5 mm diameter. Titratable acidity (TA) was determined using a digital buret (Digitrate Isolab 50 ml) by titration with 0.1 N NaOH up to pH 8.1, using 10 ml of diluted juice, and the TA was expressed as citric acid. Soluble solids were determined using a digital refractometer (Poket Pal-1, Japan). Ethylene production (μ kg^{-1} h^{-1}) and respiration rate (ml CO_2 kg^{-1} h^{-1}) were determined for fruits in a closed jar after 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 litres). The measurement of the respiratory rate was done with a gas analyzer. The ethylene production rate was determined using gas chromatography with a flame ionization detector. (Gunes et al. 2001). Statistical analyses were performed with General Linear Model using SPSS (V.16; Statistical software, SPSS. Inc., USA). Mean separation was performed using Duncan's multiple range test at $P < 0.05$ level.

Results

Fruit ripening

AVG applications delayed fruit maturation of '0900 Ziraat' sweet cherries of this study. 50 and 100 mg L^{-1} AVG-treated fruits were harvested later than 150 mg L^{-1} AVG treated fruits and control fruits. While the control fruits and 150 mg L^{-1} AVG-treated fruits harvested in 17 June 2010 and 26 June 2011, 50 and 100 mg L^{-1} AVG-treated fruits were harvested in 23 June 2010 and 30 June 2011.

Fruit size and firmness

In the both years, AVG applications significantly ($P < 0.05$) increased the fruit mass, width and length in the '0900 Ziraat' sweet cherry cultivar. The heaviest fruits were was obtained from 50 mg L^{-1} (11.50–11.53 g) and 100 mg L^{-1} (11.20–11.60 g) AVG concentration (Table 1). The effects of AVG concentrations on fruit width (mm) and length (mm) of fruits were statistically significant at the 5 % level. The largest fruits were obtained with 50 mg L^{-1} (28.2 mm in first year) and 100 mg L^{-1} (28.8 mm in second year). While all AVG concentrations improved fruit firmness, 50 mg L^{-1} AVG-treated fruits (10.7–11.5 N) induced the firmest fruits (Table 1).

Seed weight and peduncle length, thickness, weight

In both of years of this study, AVG applications decreased seed weight statistically significant ($P < 0.05$) (Table 1).

Table 1. The effect of AVG doses on some fruit characteristics in the '0900 Ziraat' sweet cherry cultivar, 2010 and 2011.

Application/ Year	Fruit width (mm)	Fruit length (mm)	Fruit weight (g)	Firmness (N)	Seed weight (g)	Peduncle length (mm)	Peduncle thickness (mm)	Peduncle weight (g)
2010								
Control	26.20 b	24.83 b	9.38 c	8.28 b	0.92 a	52.01 b	1.33 b	0.22 b
50 mg L^{-1}	28.18 a	26.21 a	11.50 a	10.76 a	0.69 b	55.85 a	1.63 a	0.24 a
100 mg L^{-1}	27.83 a	25.71 ab	11.16 ab	10.58 a	0.74 b	55.60 ab	1.62 a	0.23 b
150 mg L^{-1}	26.72 ab	25.30 ab	10.16 bc	8.55 b	0.73 b	53.75 ab	1.46 ab	0.22 b
2011								
Control	24.62 b	23.49 c	8.06 b	8.02 b	0.71 a	52.62	1.30 b	0.11 c
50 mg L^{-1}	28.67 a	26.36 a	11.53 a	11.41 a	0.61 b	56.38	1.73 a	0.19 a
100 mg L^{-1}	28.78 a	26.36 a	11.62 a	10.29 a	0.58 b	53.64	1.52 ab	0.20 a
150 mg L^{-1}	27.91 a	25.53 b	11.51 a	8.65 b	0.57 b	56.35	1.53 ab	0.14 b

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.

In the first year, AVG applications also increased peduncle length, thickness and weight. AVG had significant effects on peduncle length, thickness and weight ($P < 0.05$) (Table 1). In second year, effects of AVG concentrations on the peduncle thickness and weight were statistically significant but the effects in peduncle length was not significant ($P < 0.05$) (Table 1).

Ssc, TA and pH

Effects of AVG concentrations on soluble solid contents (SSC), titratable acidity (TA) and pH were not statistically significant in first year (Table 2). The pH, statistically difference was found between applications only for second year ($P < 0.05$) (Table 2). AVG applications increased the pH with the highest pH value in the 150 mg L^{-1} AVG (3.67) and the lowest pH in the control fruits (3.52).

Ethylene production and respiration rate

AVG applications significantly reduced the ethylene production and respiration of the cherry fruits (Table 2) in the both years. The ethylene production of control group fruits showed highest value [0.066 μL kg^{-1} h^{-1}(in first year), 0.093 μL kg^{-1} h^{-1} (in second year)], while 100 mg L^{-1} AVG fruits had the lowest value [0.043 μL kg^{-1} h^{-1} (in first and second year)]. AVG had significant effects ($P < 0.05$) on respiration rate of fruits only for second year (Table 2). The 50 and 100 mg L^{-1} AVG fruits showed the lowest respiration in the both years. The highest respiration rate (0.085–0.082 ml CO_2 kg^{-1} FM h^{-1}) was found in control fruits.

Fruit Colour (L, a*, b*)*

Effects of AVG concentrations on fruit colour (L*, a*, b*) are given in table 3 and table 4. While a significant difference between applications in terms of fruit colour a* and fruit colour b* was not observed in the first year of this study, the difference in fruit colour L* (brightness) was significant ($P < 0.05$). The highest L* value was 31.10 with 50 mg L^{-1} AVG, while the lowest L* value was 29.28 with 150 mg L^{-1} AVG in the first year (Table 2). In second year, AVG concentrations on fruit colour (L*, a*, b*) was statistically significant ($p < 0.05$) (Table 2). The 50 and 100 mg L^{-1} AVG concentrations were decreased on fruit colour (L*, a*, b*) and that the group was statistically different from other applications (in second year).

Discussion

AVG temporarily decreased ethylene production, reduced endogenous ethylene levels and delayed fruit maturation and ripening as measured by various ripening indices. This delay can have a range of benefits depending on the grower's objectives (Venburg et al. 2008). In our study, fruit maturity was delayed about 4–6 days in AVG-applied (50 and 100 mg L^{-1}) fruits (in the first and second year). The delayed harvest date of 4–6 days caused positive effect on the sweet cherry fruit quality characteristics. 50 and 100 mg L^{-1} AVG concentration with a 23–44 % increased in weight when compared to control (Table 1). The other stone fruit varieties studies have found similar our results (Rath et al. 2004, Rath and Prentice 2004, Amarante et al. 2005). Kim et al. (2004) found that AVG

Table 2. The effect of AVG doses on fruit chemical characteristics and colour characteristics in the '0900 Ziraat' sweet cherry cultivar, 2010 and 2011.

Application/ Year	SSC (%)	TA (%)	pH	Ethylene production (µL kg^{-1} h^{-1})	Respiration rate (mL $C0_2$ kg^{-1} h^{-1})	L*	a*	b*
2010								
Control	17.68	9.02	3.91	0.066 a	0.085	30.21 a b	20.87	6.79
50 mg L^{-1}	16.22	8.99	3.91	0.045 b	0.055	31.14 a	21.35	7.38
100 mg L^{-1}	18.47	9.73	3.85	0.043 b	0.051	30.46 ab	21.21	6.99
150 mg L^{-1}	17.77	9.77	3.85	0.044 b	0.060	29.28 b	21.80	7.22
2011								
Control	16.73	11.50	3.52 c	0.093 a	0.082 a	30.88 b	25.18 b	10.67 b
50 mg L^{-1}	17.03	9.83	3.61 ab	0.049 b	0.055 b	29.83 c	21.46 c	8.61 c
100 mg L^{-1}	17.00	10.31	3.56 bc	0.043 b	0.055 b	30.41 bc	22.82 c	9.25 c
150 mg L^{-1}	17.60	10.52	3.67 a	0.044 b	0.063 ab	31.89 a	27.79 a	12.60 a

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.

application increased fruit weight in the 'Mibaekdo' peach type, and Webster et al. (2006) found that 250 mg L^{-1} AVG application similar findings in the 'Colney' sweet cherry variety. The fruit size is one of the most important quality parameter in sweet cherry. The demand for sweet cherry is optimum at 10 g fruit weight and 25 mm fruit width as an average (Horvitz et al. 2003; Yildirim and Koyuncu 2010). For this reason, as the big fruits are much more flesher, they are preferred more by the consumers (Horvitz et al. 2003; Cline and Trought 2007). The highest fruit firmness was found with 50 mg L^{-1} AVG treatment. The consumer tendencies show that a firm sweet cherry is preferred much more than a soft sweet cherry (Kappel and MacDonald 2007; Chauvin et al. 2009). AVG applications also had a positive effect on increasing the firmness of the stone fruits (Launder and Jerie 2000; Singh et al. 2003; Rath et al. 2004). Çetinbaş and Koyuncu (2011) also reported that application AVG (100–150–200 mg L^{-1}) to 'Monroe' peach resulted in a reduction 7–21–30 days of harvesting time with increasing fruit firmness by 35–73 % compared to control fruits. AVG applications decreased seed weight but we think that this decreased led to from fruit flesh weight gain. Generally, in both of years, the highest peduncle length, thickness and weight value were 50 and 100 mg L^{-1} AVG-treated fruits. The sweet cherry becomes deformed more quickly than in other fruits because of the peduncle's fast water consumption and high respiration (Horvitz et al. 2003). For this reason, a long peduncle is a desired feature in sweet cherry fruits as it extends its shelf-life. AVG treatment of climacteric fruit, such as peach, apple, pear, and plum, results in reduced ethylene production and respiration rate, and fruit ripening is delayed (Launder and Jerie 2000; Singh et al. 2003; Jobling et al. 2003; Rath et al. 2004; McGlasson et al. 2005; Çetinbaş and Koyuncu 2011). However, ethylene production by non climacteric fruit is low, and changes in fruit quality during ripening are not accompanied by increased ethylene production and respiration rate (Biale and Young 1981). Sweet cherry fruit are non climacteric (Biale 1960; Blanpied 1972), and exogenous ethylene has no effect on respiration rate or firmness loss during fruit ripening (Li et al. 1994). Tian et al. (1997) found that treatment of strawberry, a non climacteric fruit, with diazocyclopentadiene (DACP) stimulated ethylene production, but did not affect respiration rate. Another study found that 1-MCP treatment of the sweet cherry cultivars 'Bing' and 'Rainier' transiently stimulated ethylene evolution but had no impact on respiration during fruit ripening (Gong et al. 2002). Our study also was determinate that AVG applications significantly reduced the ethylene production rate. Non climacteric and climacteric fruit may have different ethylene receptor (s) (McGlasson et al. 2005) and these receptor(s) may have different regulatory functions (Tian et al. 2000). AVG has effects on late ripening and also on late coloration for fruits, for this reason in our study L* value which means brightness and a* value which means redness showed same effects for 50 and 100 mg L^{-1} doses especially in studies second year data. Similar to our findings, Webster et al. (2006) found that 250 mg L^{-1} AVG application delayed the coloration in the 'Colney' sweet cherry and previous studies showed

that the effects of AVG treatment on fruit colour varied. Singh et al. (2003) found that AVG treatments had no significant effects on the fruit colour of 'Q'Henry' and 'Summerset' peach types, but that the red colour on the yellow surface increased on 'Zee Lady' peach type, implying that the effect of AVG treatments on colour development changes according to the type.

In summary, successful growing of high yields of excellent quality sweet cherry fruit on productive and precocious rootstocks, such as the 'Gisela' series, require new strategies to manage crop load (Whiting and Lang 2004). In this study, AVG decreases the ethylene production in '0900 Ziraat' sweet cherry on 'Gisela 5' rootstock by delaying maturity time of fruits and for this reason the pre-harvest AVG applications had a positive effect on sweet cherry fruit quality characteristics. Particularly, fruit maturity was delayed about 4–6 days in 50 and 100 mg L^{-1} AVG-applied fruits which caused an increase in weight ratio 23–44 %, increased the fruit firmness with a higher acceptance to the consumer. As a result, regarding effects on weight, firmness, and ethylene production as the time of application in terms at the straw-yellow stage and 50 or 100 mg L^{-1} AVG concentration for '0900 Ziraat' sweet cherry varieties can be recommended.

Conclusion

AVG (Retain®) appears a suitable pre-harvest compound to reduce premature fruit drop, improve fruit firmness and delay harvest in those commodities and countries, where it is legally approved and registered for this purpose.

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References

Amarante, C.V., T. Do, A.M.F. Drehmer, F. De Souza and P. Francescatto 2005: Preharvest spraying with gibberellic acid (GA_3) and aminoethoxyvinylglycine (AVG) delays fruit maturity and reduces fruit losses on peaches. Rev. Brasilerie de Fruticultura **27(1)**, 1–5.

Andreotti, C., A.M. Bregoli and G. Costa 2004: Pre- and post-harvest aminoethoxyvinylglycine (AVG) application affects maturity and storage of pear fruit. Europ. J. Hort. Sci. **69**, 147–152.

Autio, W.R. and W.J. Bramlage 1982: Effects of AVG on maturation, ripening, and storage of apples. J. Amer. Soc. Hort. Sci. **107**, 1074–1077.

Biale, J.B. 1960: Respiration of fruits. In: Ruhland, W. (ed.): Handbook of Plant Physiology. Springer-Verlag, Berlin, Vol. **12**/2, 536–592.

Biale, J.B. and R.E. Young 1981: Respiration and ripening in fruits-retrospect and prospect, In: Friend, J. and M.J.C. Rhodes (eds.) Recent advances in the biochemistry of fruits and vegetables. Academic Press, London, 1–39.

Blanpied, C.D. 1972: A study of ethylene in apple, red raspberry, and cherry. Plant Physiol. **49**, 627–630.

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. Physiol. Plant. **114**, 472–481.

Byers, R.E. 1997: Peach and nectarine fruit softening following aminoethoxyvinylglycine sprays and dips. Hort. Sci. **32**, 248–254.

Çetinbaş, M. and F. Koyuncu 2011: Effects of aminoethoxyvinylglycine on harvest time and fruit quality of 'Monroe' peaches. Tarım Bilimler Dergisi – J. Agric. Sci. **17**, 177–189.

Chauvin, M.A., M. Whiting and C.F. Ross 2009: The influence of harvest time on sensory properties and consumer acceptance of sweet cherries. HortTechnol. **19**, 748–754.

Cline, J.A. and M. Trought 2007: Effect of gibberellic acid on fruit cracking and quality of 'Bing' and 'Sam' sweet cherries. Can. J. Plant Sci. **87**, 545–550.

Fao 2010: Food and Agriculture Organization of The United Nations (FAO). http://www.fao.org.tr.

Gong, Y., X. Fan and J.P. Mattheis 2002: Responses of 'Bing' and 'Rainier' sweet cherries to ethylene and 1-methylcyclopropene. J. Amer. Soc. Hort. Sci. **127**, 831–835.

Gunes, G., C.B. Watkins and J.H. Hotchkiss 2001: Physiological responses of fresh-cut apple slices under high CO_2 and low O_2 partial pressures. Postharv. Biol. and Technol. **22**, 197–204.

Horvitz, S., C. Godoy, A.F. López Camelo, A.C. Yommi and C. Godoy 2003: Application of gibberellic acid to 'Sweetheart' sweet cherries: Effects on fruit quality at harvest and during cold storage. Acta Hortic. **628**, 311–316.

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. Austr. J. Exper. Agric. **43**, 515–518.

Kappel, L.F. and R.A. MacDonald 2007: Early gibberellic acid sprays increase firmness and fruit size of 'Sweetheart' sweet cherry. J. Amer. Pomol. Soc. **61**, 38–43.

Kende, H. 1993: Ethylene biosynthesis. Ann. Rev. Plant Physiol Mol Biol. **44**, 283–307.

Kim, I.S., C.D. Choi, H.J. Lee and J.K. Byun 2004: Effects of aminoethoxyvinylglycine on preharvest drop and fruit quality of 'Mibaekdo' peaches. Acta Hort. **653**, 173–178.

Launder, R. and P. Jerie 2000: In ReTain advanced fruit management. Technical manual for apples and stonefruit. Valent BioSciences, USA.

Li, S., P.K. Andrews and M.E. Patterson 1994: Effects of ethephon on the respiration and ethylene evolution of sweet cherry (*Prunus avium* L.) fruit at different development stages. Postharv. Biol. and Techn. **4**, 235–243.

Matoo, A.K., J.E. Baker, E. Chaluts and M. Lieberman 1977: Effect of temperature on the ethylene-synthesizing in apple, tomato, and *Penicillium digitatum*. Plant Cell Physiol. **18**, 715–719.

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. Postharv. Biol. and Technol. **36**, 93–102.

Park, M.Y., H.J. Kweon, I.K. Kang and J.K. Byun 1999: Effects of AVG application on harvest time extension and storability improvements in 'Tsugaru' apples. J. Kor. Soc. Hort. Sci. **40**, 577–580.

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). Austr. J. Exper. Agric. **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 Hort. **653**, 167–171.

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 Hort. **628**, 277–283.

Southwick, S.M., K. Glozer and J.T. Yeager 2006: The effect of GA, ReTain® and calcium on fruit firmness in apricot. Acta Hort. **701**, 541–544.

Tian, M.S., Y. Gong and A.D. Bauchot 1997: Ethylene biosynthesis and respiration in strawberry fruit treated with diazocyclopentadiene and IAA. Plant Growth Reg. **23**, 195–200.

Tian, M.S., S. Prakash, H.J. Elgar, H. Young, D.M. Burmeister and G.S. Ross 2000: Responses of strawberry fruit to 1-Methylcyclopropene (1-MCP) and ethylene. Plant Growth Reg. **32**, 83–91.

Venburg, G.D., R. Hopkins, J. Retamales, J. Lopez and J. Hansen 2008: Recent developments in AVG research. Acta Hort. **796**, 43–49.

Webster, A.D., J.E. Spencer, C. Dover and C.J. Atkinson 2006: The influence of sprays of gibberellic acid (GA_3) and aminoethoxyvinylglycine (AVG) on fruit abscission, fruit ripening and quality of two sweet cherry cultivars. Acta Hort. **727**, 467–472.

Whiting, M.D. and G.A. Lang 2004: 'Bing' sweet cherry on the dwarfing rootstock Gisela 5: crop load affects fruit quality and vegetative growth but not net CO_2 exchange. J. Amer. Soc. Hort. Sci. **129**, 407–415.

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

Yildirim, A. and F. Koyuncu 2010: The effect of gibberellic acid applications on the cracking rate and fruit quality in the '0900 Ziraat' sweet cherry cultivar. Afric. J. Biotechn. **9**, 6307–6311.

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