Effects of Preharvest Gibberellic Acid Applications on Fruit Quality of '0900 Ziraat' Sweet Cherry

Fatih A. Canli¹ and Hikmet Orhan

ADDITIONAL INDEX WORDS. GA₃, firmness, size, pedicel length, SSC, *Prunus avium*

SUMMARY. The objective of this study was to determine the effects of gibberellic acid (GA₃) applications on fruit quality of '0900 Ziraat' sweet cherry (*Prunus avium*), a low cropping and a large-fruited variety. '0900 Ziraat' trees were sprayed with 0, 15, 20, and 25 ppm GA₃ when the fruit were at their straw-yellow color stage. Fruit quality was evaluated at harvest in terms of size, firmness, pedicel length, and soluble solids content (SSC) to determine the optimum application. Fruit treated with GA₃ were significantly larger and firmer than the controls. There were no differences in fruit firmness within the different levels of GA₃ treatment; however, fruit treated with 20 and 25 ppm GA₃ were significantly larger than the fruit treated with 15 ppm GA₃. Trees treated with the optimum concentration of GA₃ (25 ppm) in two different locations yielded fruit with 13.4% and 14.1% greater weight and 38% and 25% higher firmness. GA₃ treatments did not affect pedicel length. The effect of GA₃ application on SSC was complex; there was a significant interaction between GA₃ and location. Being firmer than the controls, the GA₃-treated fruit could be harvested at a later date than the controls.

Sweet cherry is one of the rare nonself-fertile fruit in most parts of the world (Esti et al., 2002). Attractive, large, firm, and crack-resistant sweet cherry fruit with long pedicels are desirable to the consumers and are therefore preferred by the growers. Gibberellic acid GA₃ is used to increase the fruit firmness and the fruit size, and to delay maturity in mostly self-fertile and/or high-cropping cherry varieties in British Columbia (Kappel and MacDonald, 2002) and western North America (Looney, 1996); however, its effects on fruit of low-yielding and large-fruited varieties have not been studied.

GA₃ application resulted in variable responses in fruit quality and harvest characteristics of sweet cherry. GA₃-treated sweet cherry fruit were firmer, larger, and heavier compared with controls (Basak et al., 1998; Choi et al., 2002; Clayton et al., 2006; Facticeau, 1984, 1986; Facticeau et al., 1985a, 1985b; Horvitz et al., 2003; Kappel and MacDonald, 2002; Kupferman, 1989; Sive and Resnizky,

1988) and could be harvested later than nontreated fruit (Andrews and Shulin, 1995; Choi et al., 2002; Demirsoy and Bilgener, 2000; Facticeau et al., 1985a; Horvitz et al., 2003; Kappel and MacDonald, 2002; Webster et al., 2006). In contrast to results of Horvitz et al. (2003) and Choi et al. (2002), few researchers have reported that it also increased soluble solid concentration (SSC) (Basak et al., 1998; Lenehan et al., 2006) and the percentage of cherries with long pedicels (Horvitz et al., 2003). GA₃-treated fruit were also firmer at the end of the storage period (Clayton et al., 2003; Ozkaya et al., 2006) and delayed pedicels browning during the storage period (Ozkaya et al., 2006). The response of sweet cherry fruit to preharvest GA₃ application depended on the variety used. Application of GA₃ increased firmness, decreased fruit softening, and delayed maturity for late-maturing genotypes (135-27-17 and 'Lapins'), but did not increase firmness or delay

fruit maturity in early maturing varieties ('Merpet' and 'Celeste') (Choi et al., 2002). As in the cases of SSC and pedicel length, the response of fruit cracking to GA₃ application was also variable (Basak et al., 1998; Demirsoy and Bilgener, 1998; Looney, 1996; Usenik et al., 2005).

Some of the variable responses of sweet cherries to GA₃ is probably due to environmental factors such as temperature, precipitation, humidity, water status, nutrition, and light (Facticeau et al., 1985b) or to the use of different varieties (Usenik et al., 2005). Time of application and dose may also be important. For example, the time of application for variety 'Bing' is about 3 weeks before harvest, whereas for 'Sweetheart', the straw-yellow developmental stage of fruit is about 5 weeks before the harvest time (Kappel and MacDonald, 2002).

The sweet cherry variety '0900 Ziraat' constitutes about 12% of the world cherry trade (Ergun and Burak, 2001). The most consistent effect of GA₃ application is to increase fruit size and firmness and to delay maturity; however, Demirsoy and Bilgener (1998) reported that GA₃ application 35 d before the harvest date had not increased the fruit size and firmness in '0900 Ziraat' sweet cherry. This is most probably caused by the too early application of GA₃ in the season and at a too early stage of the fruit development. The objective of this study was to determine if the preharvest GA₃ application at the straw-yellow stage (about 21 d before the harvest) of '0900 Ziraat' fruit will increase the fruit size and firmness in this variety, which makes up an important part of the cherry trade in the world.

Materials and methods

The experiments were conducted in 2004 using 6-year-old trees of '0900 Ziraat' sweet cherry in two different locations in Turkey. The first location was an experimental research field of Egirdir Horticultural

We thank Egirdir Horticultural Research Institute and Mehmet Coban for opening the cherry orchards for the project, and Ismail Demirtas for his help with the various aspects of this study.

Faculty of Agriculture, Suleyman Demirel University, Cunur/Isparta, Turkey

¹Corresponding author. E-mail: canlifat@ziraat.sdu.edu.tr.

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.3048	ft	m	3.2808
25.4	inch(es)	mm	0.0394
0.4536	lb	kg	2.2046
28.3495	oz	g	0.0353
1	ppm	mg·L ⁻¹	1

Research Institute located in Egirdir and the second was a commercial orchard in Isparta.

The experiments were designed in a completely randomized design with four single-tree replicates for each treatment. Mature '0900 Ziraat' sweet cherry trees (about 3 m in diameter and grown on Mazzard rootstocks) were sprayed to runoff using a handgun applicator when the fruit were at their straw-yellow stage of development (about 21 d before harvest). The sprays were completed on a nonwindy day in the afternoon between 1700 and 1800 HR. Treatments included a single application of 0, 15, 20, or 25 ppm GA₃ (Perplex; Platin Kimya, Istanbul, Turkey). All trees were harvested when the controls were considered to be mature at each location.

For each replication, 80 fruit were sampled randomly to determine the average fruit weight, fruit firmness, SSC, and pedicel length. Fruit firmness was measured at a position located at the fruit's maximum width using a firmness tester (model FT 001 Fruit Pressure Tester; Gullimex, Alfonsine, Italy) with a 4.94 mm diameter probe.

The pedicels were removed and the juice was obtained by mashing fruit in a plastic bag. The SSC of the fruit juice was determined using a refractometer (model N.O.W. 507-1; Nippon Optical Works, Tokyo) with a °Brix scale of 0 to 32. Pedicel length was determined using a digital caliper.

Analyses of variance were performed on pedicel length, fruit weight, firmness, and SSC, and then means were subjected to mean separation by Duncan's multiple range tests using SAS (SAS Institute, Cary, NC).

Results and discussion

The effect of GA₃ on fruit size and fruit firmness were found to be significant, but no differences were observed between control and treated fruit with respect to pedicel length (Table 1). The effect of preharvest GA₃ spray on SSC of the fruit was more complex, and there was a significant interaction between GA₃ treatment and location (Table 1).

In Egirdir, the GA₃-treated fruit was larger than control fruit (in fruit weight) and there were also significant differences within different

Table 1. Effects of different levels of gibberellic acid (GA₃) applications at the straw-yellow stage on fruit quality (average fruit weight, fruit firmness, pedicel length, and soluble solids) of '0900 Ziraat' sweet cherry in Egirdir and Isparta, Turkey.

	GA ₃ treatment (ppm) ^z	Avg fruit wt (g) ^z	Fruit firmness (kg) ^z	Pedicel length (mm) ^z	Soluble solids (%)
Egirdir	0	10.32 d ^y	1.29 b	62.32	19.20
	15	10.80 c	1.79 a	63.02	19.50
	20	11.22 b	1.70 a	63.00	18.13
	25	11.70 a	1.78 a	62.00	19.80
Isparta	0	8.45 c	1.10 b	48.89	18.43 d
	15	9.16 b	1.41 a	49.56	20.35 a
	20	9.58 a	1.35 a	50.07	19.32 c
	25	9.64 a	1.37 a	48.53	19.87 b
GA ₃ × location interactions		NS	NS	NS	*

^z1 ppm = 1 mg·L⁻¹, 1 g = 0.0353 oz; 1 kg = 2.2046 lb; 1 mm = 0.0394 inch.

^yMean separation by Duncan's multiple range test at *P* ≤ 0.05.

^{ns} * Nonsignificant or significant at *P* ≤ 0.05, respectively.

levels of the GA₃-treated fruit (Table 1). Regardless of the GA₃ concentrations, fruit treated with GA₃ were larger than the control, and 25 ppm GA₃ application yielded larger fruit than other GA₃ levels (Table 1). In Isparta, the GA₃-treated fruit was also larger than control fruit, but there was no significant difference between 20 ppm and 25 ppm GA₃ applications. The largest fruit sizes were obtained from 20 and 25 ppm GA₃ applications in Isparta (Table 1). The GA₃ application showed similar effects on the mean fruit weight in both locations, and there was no statistically significant interaction between GA₃ application and locations with respect to mean fruit weight (Table 1). Trees treated with the optimum level of GA₃ (25 ppm) yielded fruit with 13.4% and 14.1% greater weight in Egirdir and Isparta, respectively (Table 1). One of the most important benefits of preharvest GA₃ application is a reliable increase of fruit size of about 10% to 15% (Lenahan et al., 2006; Looney, 1996). A similar gain in fruit size as a response to GA₃ applications was reported by other researchers (Cline and Trought, 2007; Kappel and MacDonald, 2002; Lenahan et al., 2006; Looney, 1996; Usenik et al., 2005).

When compared with untreated control fruit, all GA₃ treatments increased fruit firmness in Egirdir and Isparta (Table 1). No significant differences in fruit firmness were observed among the GA₃ levels in either location (Table 1). As in fruit weight, no significant interaction

observed between GA₃ treatment and location with respect to their effects on fruit firmness and GA₃ had the same effect on fruit firmness in either location (Table 1). The result on increased fruit firmness obtained with GA₃ applications in this study is consistent with the results of the other researchers (Cline and Trought, 2007; Facticeau, 1986; Kappel and MacDonald, 2002; Kupferman, 1989; Lenahan et al., 2006; Ozkaya et al., 2006; Usenik et al., 2005).

The most consistent effects of the preharvest GA₃ application are to increase fruit size and firmness and to delay maturity; however, in contrast with our results and with the many others, Demirsoy and Bilgener (1998) reported that GA₃ application did not increase the fruit size and firmness in '0900 Ziraat' sweet cherry. Their results are most probably due to the time of application: they applied GA₃ 35 d before the harvest. This time of application was very early for this variety, and, therefore, potentially ineffective. We have shown that if GA₃ is applied later in the season when the fruit was at the straw-yellow stage [about 21 d before the harvest as it is in 'Bing' (Kappel and MacDonald, 2002)], it was very effective in increasing fruit size and fruit firmness in both of the locations.

Few researchers also observed an increase in SSC as a response to GA₃ application (Basak et al., 1998; Lenahan et al., 2006). In our case, the effect of GA₃ on SSC was complex (Table 1). The interaction between location and GA₃ application was

significant (Table 1); for example, 15 and 20 ppm GA₃ sprays resulted in fruit with higher SSC in Isparta, but GA₃ had no effect on SSC at any level of GA₃ in Egirdir (Table 1). The responses were variable on the effects of GA₃ on SSC and there are not always changes in SSC (Facteau et al., 1985b; Kappel and MacDonald, 2002).

It has been reported that GA₃ spray increased the percentage of cherries with long pedicels (Horvitz et al., 2003) and delayed the pedicel discoloration during the storage period (Ozkaya et al., 2006). In our study, location was an important factor that effected pedicel length, and fruit had longer pedicel in Egirdir (Table 1). There were no significant differences observed between the mean pedicel lengths of fruit from controls and GA₃ treatments in Egirdir and in Isparta (Table 1). There was no interaction between locations and GA₃ treatment regarding pedicel length (Table 1).

In conclusion, the preharvest application of GA₃ in the '0900 Ziraat' sweet cherry at the straw-yellow stage increases the fruit size and firmness. Among the concentrations tested, the 25 ppm GA₃ application appeared to be the optimum concentration to increase the firmness and fruit size of this variety. Being firmer than the control, GA₃-treated fruit can be harvested at a later date than the untreated fruit.

Literature cited

Andrews, P.K. and L. Shulin. 1995. Cell wall hydrolytic enzyme activity during development of nonclimacteric sweet cherry (*Prunus avium* L.) fruit. *J. Hort. Sci.* 70:561–567.

Basak, A., E. Rozpara, and Z. Grzyb. 1998. Use of bioregulators to reduce sweet cherry tree growth and to improve fruit quality. *Acta Hort.* 468:719–723.

Choi, C., P.A. Wiersma, P. Toivonen, and F. Kappel. 2002. Fruit growth, firmness and cell wall hydrolytic enzyme activity

during development of sweet cherry fruit treated with gibberellic acid (GA₃). *J. Hort. Sci. Biotechnol.* 77:615–621.

Clayton, M., W.V. Biasi, I.T. Agar, S.M. Southwick, and E.J. Mitcham. 2003. Post-harvest quality of 'Bing' cherries following preharvest treatment with hydrogen cyanamide, calcium ammonium nitrate, or gibberellic acid. *HortScience* 38:407–411.

Clayton, M., W.V. Biasi, I.T. Agar, S.M. Southwick, and E.J. Mitcham. 2006. Sensory quality of 'Bing' sweet cherries following preharvest treatment with hydrogen cyanamide, calcium ammonium nitrate, or gibberellic acid. *HortScience* 41:745–748.

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.

Demirsoy, L. and S. Bilgener. 1998. The effect of preharvest chemical applications on cracking and fruit quality in '0900 Ziraat', 'Lambert' and 'Van' sweet cherry varieties. *Acta Hort.* 468:663–670.

Demirsoy, L. and S. Bilgener. 2000. The effect of chemical applications on cuticular and epidermal properties of some sweet cherry cultivars with respect to fruit cracking susceptibility. *Turkish J. Agr. For.* 24:541–550.

Ergun, M.E. and M. Burak. 2001. I. Sert cekirdekli meyve sempozyumu. Tarım ve Koyisleri Bakanlığı, Yayın Dairesi Başkanlığı, Yalova, Turkey.

Esti, M., L. Cinquanta, F. Sinesio, E. Moneta, and M.D. Mateo. 2002. Physicochemical and sensory fruit characteristics of two sweet cherry cultivars after cool storage. *Food Chem.* 76:399–405.

Facteau, T.J. 1984. Sweet cherry trials. Internal Rpt., Marlborough Research Centre, Blenheim, New Zealand.

Facteau, T. 1986. Effects of calcium, GA on cherries studied. *Good Fruit Grower* 37:27–28.

Facteau, T.J., K.E. Rowe, and N.E. Chestnut. 1985a. Firmness of sweet cherry fruit following multiple applications of gibberellic acid. *J. Amer. Soc. Hort. Sci.* 110:775–777.

Facteau, T.J., K.E. Rowe, and N.E. Chestnut. 1985b. Response patterns of gibberellic acid-treated sweet cherry fruit at different soluble solids levels and leaf/fruit ratios. *Scientia Hort.* 27:257–262.

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

Kappel, F. and R.A. MacDonald. 2002. Gibberellic acid increases fruit firmness, fruit size, and delays maturity of 'Sweetheart' sweet cherry. *J. Amer. Pomol. Soc.* 56:219–222.

Kupferman, E.M. 1989. Cherry warehouse survey shows value of GA use. *Good Fruit Grower* 40:10–13.

Lenahan, O.M., M.D. Whiting, and D.C. Elfving. 2006. Gibberellic acid inhibits floral bud development and improves 'Bing' sweet cherry fruit quality. *HortScience* 41:654–659.

Looney, N.E. 1996. Principles and practice of plant bioregulator usage in cherry production, p. 279–298. In: A.D. Webster and N.E. Looney (eds.). *Cherries: Crop physiology, production and users*. CAB International, Wallingford, UK.

Ozkaya, O., O. Dundar, and A. Kuden. 2006. Effect of preharvest gibberellic acid treatments on postharvest quality of sweet cherry. *J. Food Agr. Environ.* 4:189–191.

Sive, A. and D. Resnizky. 1988. Storage trials with several cherry cultivars in 1987. *Alon Hanotea* 42:869–877.

Usenik, V., D. Kastelec, and F. Stampar. 2005. Physicochemical changes of sweet cherry fruits related to application of gibberellic acid. *Food Chem.* 90:663–671.

Webster, A.D., J.E. Spencer, C. Dover, and C.J. Atkinson. 2006. The Influence of sprays of gibberellic acid (GA₃) and aminoethoxyvinylglycine (Avg) on fruit abscission, fruit ripening and quality of two sweet cherry cultivars. *Acta Hort.* 727:467–472.