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Gibberellic Acid Increases Fruit Firmness, Fruit Size, and Delays Maturity of 'Sweetheart' Sweet Cherry

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Abstract

Growers in British Columbia, Canada and the US Pacific Northwest use gibberellic acid (GA_3) to improve fruit quality of sweet cherries (*Prunus avium* L.). A single spray application of about three weeks before harvest has become the standard procedure. The objective of this trial was to determine if multiple applications of GA_3 can further increase fruit firmness and size, and delay maturity of 'Sweetheart' sweet cherry, the second most important sweet cherry cultivar in British Columbia. Yield was not affected by a single application of 20 or 30 ppm or two or three weekly applications of 10 ppm GA_3 in any of the three years of the trial. Fruit treated with GA_3 were significantly firmer than fruit not treated; however, there were no differences in fruit firmness amongst the single or multiple GA_3 treatments. Titratable acidity of GA_3-treated fruit was significantly higher than that of untreated fruit. There were no differences in titratable acidity within the GA_3 treated fruit. Fruit treated with GA_3 were significantly larger than untreated fruit and the fruit treated with 20 ppm GA_3 were larger than the fruit treated with 30 ppm GA_3 (single applications). In summary, GA_3-treated fruit could be harvested later and were larger and firmer than untreated fruit. There was no benefit to multiple applications of GA_3 relative to a single application.

Introduction

Use of gibberellic acid (GA_3) in fresh market sweet cherry production has become a standard practice in British Columbia and other production areas in western North America (5). It is used to delay maturity and increase fruit firmness and size. GA_3 applications also reduce levels of fruit surface pitting (2,6) and improve the quality of canned 'Rainier' cherry (7).

The general recommendation is to apply 20 ppm of GA_3 at the straw-yellow stage of fruit development. For 'Bing' cherry this is generally about three weeks before harvest, but for 'Sweetheart' the straw-yellow stage is about five weeks before normal harvest. Facteau et al. (3) found that multiple and single applications on 'Bing' and 'Lambert' had similar results as long as the total dose was the same. There are anecdotal reports that suggest that 'Sweetheart' may respond differently to multiple applications of GA_3. The objective of this trial was to determine if multiple applications of GA_3 increase firmness and delay maturity of 'Sweetheart' sweet cherry.

Materials and Methods

Whole 'Sweetheart' cherry trees (planted in 1988) were sprayed to run-off using a hand-gun applicator beginning when the developing fruit were at straw-yellow stage or beginning to turn pink (Table 1). Treatments included a single application of 20 or 30 ppm GA_3 (Activol; Norac Concepts Inc., Burlington, Ont.), 10 ppm applied twice or 10 ppm applied three times. All single applications and the first of the multiple applications were applied at the straw yellow color stage. The remaining multiple applications were applied 5 to 8 days after the previous spray. Two trees per replicate were sprayed with each treatment. This allowed for two harvests. One tree was harvested when the unsprayed controls were considered to be mature and the second tree was harvested 6 days later. The same trees received the same treatments each year.

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Fruit firmness was determined using a FirmTech fruit firmness measuring device (BioWorks, Stillwater, Okla.) (25 fruit per rep). For each rep a 100 fruit sample was randomly selected and number of fruit with rain splits and average fruit weight was determined. The stems were then removed and the juice was expressed by crushing the fruits in a plastic bag. Total soluble solids concentration (SSC) of the juice was measured using an ABBE Mark II digital refractometer (AO Scientific Instruments, Keene,. N.H.). The pH was measured and the titratable acidity (TA) of a 10-mL sample of juice was measured using a 719 S Titrino autotitrator (Metrohm, Herisau, Switzerland). The milliliters of 0.1 N naOH required to bring the pH to 8.1 was determined and TA is expressed as % malic acid.

The experiment was designed as a completely randomized design with 5 replicates. The data were analyzed as a split plot with GA_3 treatments, harvest time, and year as main effects. Data were analyzed by the general linear model procedure and planned contrasts were used to compare means of the main effects (SAS Institute, Cary, N.C.).

Results

The attempt was made to time the first spray when the majority of the fruit were at the straw-yellow stage. We were successful only in 1999 when 51% of the fruit were at the straw-yellow stage (Table 1) whereas in 1997 62 % of the fruit were classified as pink.

There were no significant interactions for yield and none of the contrasts were significant (Table 2). Yield was not affected by GA_3 treatment, only by harvest and year. Trees that were harvested first had higher yields than trees harvested about a week later. Fruit drop between the two harvest dates may have affected the yield, however fruit numbers at the two harvests were not counted. Year had the greatest effect with lowest yields in 1998 and highest in 1999.

The year x treatment interaction was highly significant for fruit firmness. In each year GA_3-treated fruit were firmer than the control fruit. However, in 1997 and 1998 the fruit treated with 20 ppm were the firmest (315 and 298 g/mm respectively), and in 1999 the fruit treated with 10 + 10 + 10 ppm were the firmest (324 g/mm). In each year the control fruit were the softest, with firmness measurements of 272, 213, and 280 g/mm in 1997, 1998, and 1999 respectively. Fruit firmness was significantly affected by all the main effects, that is GA_3 treatment, time of harvest, and year. All GA_3-treated fruit were firmer than the control fruit. Fruit from the first harvest were firmer than fruit harvested a week later and fruit from the 1998 harvest were softest. The contrast, control vs. GA_3 treatment was significant for fruit firmness with the firmness of control fruit 255 g/mm and the average for the GA_3 treated fruit 306 g/mm.

Rain cracking was only affected by year with the most severe cracking in 1997. There was 2.5 and 3.5 times more rain in 1997 in the period from 1 June until first harvest than in 1998 and 1999 respectively.

The year x treatment interaction was highly significant for SSC. The SSC of the GA_3-treated fruit in 1997 and 1998 tended to be similar to the control, whereas in 1999 the GA_3-treated fruit had higher SSC values than the control fruit. Fruit from the second harvest had significantly higher SSC readings than the first harvest and fruit from 1998 had higher SSC readings than either 1997 or 1999. GA_3 did not affect SSC levels significantly.

The harvest x treatment interaction was significant for pH. The pH of GA_3-treated fruit from the second harvest was higher than the pH of the treated fruit from the first harvest which tended to be lower or similar to the control pH. The year x treatment interaction was highly significant for fruit pH. In 1997 the pH readings of GA_3-treated fruit were for the most part higher than the readings for the control fruit. In 1998 the readings were similar or slightly lower. The treatment x harvest x year interaction was highly significant for pH. Fruit pH was significantly affected by treatment, harvest, and year. All the con-

Table 1. Dates of gibberellic acid application and harvest, and stage of fruit development of 'Sweetheart' sweet cherry.

	Year		
	1997	1998	1999
Date of first spray	30 June	17 June	25 June
Days before harvest	36	36	39
Percent of fruit at the various color stages at time of GA application			
green	13	39	46
straw-yellow	25	39	51
pink	62	22	3
Date of second spray	7 July	23 June	30 June
Days before harvest	29	30	34
Date of third spray	14 July	29 June	6 July
Days before harvest	22	24	28
Date of first harvest	5 Aug	23 July	3 Aug.
Date of second harvest	11 Aug	29 July	9 Aug

trasts for pH except 10 + 10 vs 10 + 10 + 10 ppm were significant.

The year x treatment interaction was highly significant for TA. Titratable acidity readings in 1997 and 1998 for GA_3-treated fruit were higher than those of the controls; in 1999 the readings were similar. TA was affected by treatment and year but not by harvest. Control fruit had significantly lower TA readings than GA_3-treated fruit and TA in 1997 was significantly lower than the other two years. The contrast, control vs. GA_3 treatment, was significant for TA with control fruit having a TA of .904 % malic acid whereas the average TA for the GA_3-treated fruit was 1.058 % malic acid.

There were no significant interactions for average fruit weight. Average fruit weight was affected by treatment and year but not by harvest. All GA_3-treated were larger than control fruit and fruit in 1999 were larger than fruit from the other years. The contrast control vs GA_3 treatment was significant with GA_3-treated fruit larger than control fruit (10.8 g and 9.8 g, respectively). Fruit treated with 20 ppm GA_3 (11.0 g) were also larger than fruit treated with 30 ppm (10.6 g).

Discussion

The current timing for the GA_3 spray for 'Bing' cherry at the straw-color stage generally is about three weeks before harvest. However, for 'Sweetheart' the straw-color stage is closer to five weeks before harvest. It is generally thought that the start of Stage II of fruit development (the lag-phase) coincides with the straw-color stage. 'Sweetheart' matures about three weeks after 'Bing' and this later maturity is likely due to a longer lag-phase.

One of the most important effects of GA_3 has been the increase in firmness of the fruit. Fruit treated with GA_3 were 20% firmer than control fruit. This is similar to the reports of Facteau (1), Facteau et al. (3), Kondo et al. (4), and Proebsting et al. (7). Fruit firmness is an important criterion for fresh fruit quality of sweet cherries. Increased firmness of sweet cherries induced by GA_3 may be related to increased alcohol-insoluble substances, higher pectinase-soluble pectins, and lower concentration of water-soluble pectins (1). The firmness of treated fruit at the second harvest was greater than the firmness of control fruit at the first harvest even though firmness decreased from the first to the second harvest.

The reason for the difference in yield from the first harvest to the second harvest is unknown. There may have been an increased fruit drop from the first to the second pick. We did not count the number of fruit at each harvest and we did not note an increased level of fruit drop over that period.

The delay in maturity caused by GA_3 is another valuable characteristic for northern sweet cherry growers. The delay in harvest of five to seven days due to GA_3 treatment and the late ripening nature of 'Sweetheart', results in increased prices for the growers because of the decreasing supply and strong demand for sweet cherries at this time of the season. The GA_3 treatment did not affect SSC of fruit harvested at the same time, but fruit harvested one week later had higher SSC levels.

The GA_3 treatment increased fruit size, delayed ripening and increased fruit firm-

Table 2. Yield, fruit firmness, rain-induced cracking response, total soluble solids concentration, pH, titratable acidity, and fruit size of 'Sweetheart' sweet cherry treated with gibberellic acid.

Main effects	Yield (kg/tree)	Fruit firmness (g/mm)	Rain cracking (%)	Total Soluble solids (%)	pH	Titratable acidity (% malic acid)	Average fruit size (g)
GA Treatment							
Control	5.65	255	30	19.8	3.95	.904	9.8
20 ppm	6.53	311	26	19.6	3.83	1.085	11.0
30 ppm	5.93	305	26	19.6	3.90	1.059	10.6
10 + 10 ppm	5.17	302	30	20.1	3.95	1.065	10.9
10 + 10 + 10 ppm	5.50	304	27	20.1	3.96	1.025	10.8
Significance	NS[z]	***	NS	NS	***	***	***
Harvest							
First	6.30	306	26	19.2	3.86	1.025	10.7
Second	5.21	285	29	20.5	3.97	1.025	10.6
Significance	*	***	NS	***	***	NS	NS
Year							
1997	5.99	301	52	19.5	4.18	.858	10.4
1998	4.02	274	17	20.6	3.78	1.179	10.2
1999	7.08	310	15	19.4	3.79	1.038	11.3
Significance	***	***	***	***	***	**	***
Interactions							
Harvest X treat.	NS	NS	NS	NS	*	NS	NS
Year X treat.	NS	NS	NS	***	***	***	NS
Treat. X harvest X year	NS	*	NS	NS	***	NS	NS
Contrasts							
Control vs GA trt.	NS	***	NS	NS	*	***	***
20 vs 30 ppm	NS	NS	NS	NS	***	NS	NS
20 vs 10+10 ppm	NS	NS	NS	NS	***	NS	NS
30 vs 10+10+10ppm	NS	NS	NS	NS	**	NS	NS
10+10 vs 10+10 +10 ppm	NS	NS	NS	NS	NS	NS	NS
single vs multiple	NS	NS	NS	NS	***	NS	NS

[z]NS, *, **, *** = Not significant or significant at $P \leq 0.05$, 0.01, or 0.001 respectively.

ness. However, multiple GA_3 treatments did not provide any additional benefit for 'Sweetheart' which is similar to the findings of Facteau et al. (3) for 'Bing' and 'Lambert'.

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