Project title: New tactic for suppressing cracking of cherries
PI: Larry Schrader
Organization: Tree Fruit Research and Extension Center, WSU-Wenatchee
Address: 1100 N. Western Avenue, Wenatchee, WA 98801
Phone: (509) 663-8181, Ext. 265
E-mail: Schrader@wsu.edu

CO-PI(s): Matthew D. Whiting
Organization: Irrigated Agriculture Research & Extension Center, WSU-Prosser

Cooperators: Yugang Sun¹, Jianshe Sun¹, Leo Jedlow¹, and David Ophardt²
¹ Tree Fruit Research and Extension Center, WSU-Wenatchee
² Irrigated Agriculture Research & Extension Center, WSU-Prosser

Objectives:
1. Determine efficacy of spraying a new formulation to repel water from cherries. The formulation will be hydrophobic (lipophilic) and contain an osmoregulator (e.g., calcium chloride).
2. Study timing and rates of application of the formulation.
3. Investigate fruit cracking under microscopes and determine the effect(s) of calcium and the hydrophobic formulation.
4. Determine whether fruit quality and appearance are altered by the formulation.

Significant findings:
These findings are divided into three categories:
I. Several factors were discovered to influence the rate and amount of cracking.
   A. Cherry cracking increased as air and fruit surface temperature increased. Surface temperatures of sun-exposed fruit in the field exceeded air temperature by as much as 10.2°C (over 18°F) (See Fig. 1).
   B. ‘Bing’ cherries immersed in deionized water (similar to rain water) held at 40°C (104°F), 30°C (86°F) or at 22°C (72°F) cracked far more quickly at 104°F than at 72°F (See Fig. 2).
   C. Water quality affected cherry cracking. Cracking was delayed in city water, irrigation water, and in sugar solution as compared to deionized water (Fig. 3). This is due to the higher salt concentration (and higher osmotic concentration) of these waters as compared to rainwater or deionized water.
   D. Water absorption by cherries also was most rapid when immersed in deionized water and was delayed in sugar solution and city water (Fig. 4).
II. Applying two new formulations (also called matrix) to cherries showed promise in suppressing cracking.
   A. One of the formulations applied at 10% or 20% (v/v) reduced water absorption when applied to cherries prior to immersion of cherries in deionized water (Fig. 5).
   B. One of the formulations also substantially reduced cracking of ‘Bing’ cherries immersed in deionized water for up to 9 hours (Fig. 6).
   C. One of the formulations reduced cracking and also delayed cracking of the stem bowl in ‘Bing’ cherries that were inverted and partially submerged at 30°C (86°F) and 45°C (113°F) (Fig. 7).
   D. Results obtained with the stem bowl in ‘Rainier’ cherries at 30°C (86°F) and 45°C (113°F) were similar to results cited in C above (Fig. 8).
E. In a field experiment with ‘Bing’ cherries, one formulation significantly reduced cracking from 29.6% in the control to 15.4% (P<0.01), and another formulation decreased cracking to 9.3% (P<0.01) (Fig. 9). However, formulation II provided a better appearance to the treated cherries than did the other.

III. The formulation also showed promise for reducing water loss from cherries post-harvest.
   A. Water loss from harvested ‘Sweetheart’ cherries was decreased by applying the formulation immediately after harvesting fruit either with or without the pedicel (stem) attached to the fruit (Fig. 10).
   B. We observed better retention of green stems (pedicels) on the cherries to which the formulation was applied, except in one experiment with ‘Sweetheart’ cherries.

Methods:
The methods described below are organized to correspond to each figure presented in the Results and Discussion section.

Fig. 1—Air temperature vs. cherry fruit surface temperature—Thermocouples connected to a Campbell Scientific CR10X data logger were attached to ‘Sweetheart’ cherries to record fruit surface temperature on the southwest side of fruit (full sun exposure in afternoon) throughout the day at 5-minute intervals. A thermocouple placed in the shade recorded air temperature. This study was conducted 3 weeks before fruit maturity on ‘Sweetheart’ cherries in a Wenatchee Heights orchard.

Fig. 2—Effect of water temperature on cherry cracking—Ninety ‘Bing’ cherries of uniform size and maturity were harvested and separated into nine sample lots of 10 each. Each lot was placed in a separate beaker containing deionized water. Three beakers were maintained at 40ºC (104ºF), three were maintained at 30ºC (86 ºF), and three were maintained at 22ºC (72ºF). All fruits were examined at 30-minute intervals for cuticle cracking, and cracked fruits were removed from the beakers.

Fig. 3—Effect of water quality on cherry cracking—‘Bing’ cherries of uniform size and maturity were harvested and separated into four lots of 30 each. Each lot was placed in a separate beaker. One beaker contained deionized water (DW) at 22ºC (72ºF); another contained city water (CW) at 22ºC; another contained a 10% (w/v) sucrose solution (SS) at 22ºC; and another contained irrigation water (IW) at 16ºC (61ºF). All fruits were examined at 30-minute intervals for cuticle cracking, and cracked fruits were removed from the beakers.

Fig. 4—Effect of water quality on water absorption in cherries—‘Bing’ cherries of uniform size and maturity were harvested, separated into nine lots of 10 each, dipped in deionized water, blot dried, and weighed. Three lots were immersed in deionized water (DW) at 22ºC (72ºF); three were immersed in city water (CW) at 22ºC; and three were immersed in 10% (w/v) sucrose solution (SS) at 22ºC. Every 2 hours, each cherry lot was removed from solution, blot dried, reweighed, and recorded. Water absorption was calculated as percent change in weight.

Fig. 5—Effect of matrix on water absorption in cherries—‘Bing’ cherries of uniform size and maturity were harvested and separated into nine lots of 10 fruits each. Three lots were dipped quickly into 10% (v/v) Formulation II, three into 20% (v/v) Formulation II, and three into deionized water (DW). All fruits dried overnight at 22ºC and were weighed before immersion in DW. Every 2 hours, each cherry lot was removed from the DW, blot dried, and weighed. Water absorption was calculated as percent change in weight.

Fig. 6—Effect of matrix on cherry fruit cracking—The materials and methods were similar to those in Fig. 5, except that the cherries were examined for cracking after 9 and 11 hours in deionized water.
Fig. 7 and 8—Effect of matrix and temperature on cracking of cherries at the stem bowl—‘Bing’ and ‘Rainier’ cherries of uniform size and maturity were harvested and separated into two lots of 60 for each cultivar. One lot of each cultivar was dipped into 20% (v/v) Formulation II, and the other was dipped into deionized water (DW). The fruit dried at room temperature overnight. The fruit pedicel (stem) of each cherry was cut so that only 0.5 cm remained. Plastic containers were prepared with four layers of absorbent paper; DW was added to a level sufficient to cover the paper and the cherry shoulders when they were immersed in an inverted position. Treated fruits and controls were maintained separately at 30ºC (86ºF) and 45ºC (113ºF) and were examined for cracking at 30-minute intervals.

Fig. 9—Suppression of cherry cracking in the field—Four ‘Bing’ cherry tress of uniform growth and vigor were selected. Three branches of each tree were sprayed 2 weeks before harvest with one of the following treatments: 10% (v/v) Matrix II, 20% (v/v) Matrix I, or DW (control). Overhead sprinklers were installed in each tree, and deionized water was pumped through the nozzles with an electric pump to provide 0.4 gallons water/minute per nozzle. In some cases, four nozzles per tree were installed to wet the fruit for at least 2 hours. Fruits were evaluated for cracking the next day.

Fig. 10—Effect of formulation on water loss with and without pedicel (stem)—Two hundred ‘Sweetheart’ cherries of uniform size and maturity were harvested. The pedicel was removed from 100 of the cherries; 50 were immersed in 10% (v/v) Formulation II and 50 were immersed in DW. The other 100 fruits with pedicel attached were split and treated as above. All treatments were transported from the field to the laboratory (approx. 45 minutes), and then rinsed with DW, blot dried, grouped in lots of 10, and weighed. The various lots were held at 22ºC and reweighed at various times; the percent water loss was recorded as a percent change in weight.

Results and discussion:

Field experiments: Initially, ‘Chelan’ cherries at various stages of maturity were sprayed with deionized water for 1 to 2 hours using backpack sprayers. However no cracking was observed. We then went to larger equipment in which an electric pump was used to pressurize a system that included microsprinklers installed within the tree canopy. We transported deionized water from the laboratory to the field in 55-gal plastic drums and applied 6 drums (330 gal.) of water in each experiment. In early experiments, we were unable to crack the cherries, but after revamping the system to direct more water onto the fruit from four microsprinklers we were successful in cracking ‘Bing’ cherries. In the meantime, we conducted some laboratory experiments to learn more about factors that contribute to cherry cracking. These experiments were helpful and some are described below.

We used thermocouples on fruit in the field to determine the relationship between air temperature and fruit surface temperature. We found that fruit surface temperature on the sun-exposed side of a cherry can be as much as 18ºF warmer than air temperature (see Fig. 1). The differential between air and fruit temperature was larger than we expected and helps explain why cherries are more likely to split when the sun comes out and air temperature rises rapidly after a rain.

We examined the effects of temperature by immersing ‘Bing’ cherries in beakers of deionized water held constant at several temperatures (see Fig. 2). The effects of temperature are striking. At 104ºF, all fruit cracked within 1.5 hours, whereas it took 3 hours at 86ºF and 6.5 hours at 72ºF.

Water quality also affected cracking. Cracking was delayed by city water, irrigation water, and a sugar solution as compared to deionized water (see Fig. 3). The electrical conductivity of city water, irrigation water and sugar solution was considerable whereas deionized water was near zero.
Water absorption by ‘Bing’ cherries was also influenced by water quality. Water absorption was decreased by city water and sugar solution relative to deionized water (see Fig. 4). Water absorption was also decreased by applying Formulation II to ‘Bing’ cherries before they were immersed in water (See Fig. 5).

Formulation II also substantially reduced cracking of ‘Bing’ cherries after 9 hours in water (see Fig. 6). In a specially designed experiment in which fruits were inverted on wet paper towels whose temperature was controlled at either 86°F or 113°F, cracking of the stem bowls was decreased and delayed by the formulation (see Fig. 7 for ‘Bing’ and Fig. 8 for ‘Rainier’).

In a field experiment, cracking of ‘Bing’ cherries was significantly reduced by two formulations (see Fig. 9). We tested two formulations, but chose to use Formulation II for most experiments, as it provided an attractive sheen on the cherries. We were unsuccessful in inducing cracking in ‘Lapins’ and ‘Rainier’ trees in the same orchard. We also had little success in cracking ‘Chelan’ or ‘Sweetheart’ cherries in the field. Thus, we need to improve our techniques further to induce a higher incidence of cracking. From our laboratory studies, we have findings that will help us modify our techniques.

In a different experiment designed to suppress post-harvest water loss from cherries, we harvested cherries directly into a container of the formulation. Half of the cherries had a pedicel (stem) and half did not. We harvested an equal number of fruits and placed them in a container of water (control). The fruits were transported to the laboratory, and all were rinsed with deionized water. Fruits were retained at 72°F for 72 hours. They were weighed periodically during that period to determine water loss (see Fig. 10). The green color of the stems was also examined, but differences were small. It should be noted, however, that the formulation was only on the fruit for 45 minutes before rinsing. We reasoned that if we left the fruit in the formulation longer, it would not simulate what a grower might experience when taking the fruit to storage. If we can design a method to keep the formulation on the fruit longer, we will likely see a bigger effect of the formulation on both stem color and water retention by the fruit.

Dr. Whiting compared Formulation I to an untreated control on several cherry cultivars in the field. He tested ‘Chelan,’ ‘Bing,’ ‘Liberty Bell,’ and ‘Sweetheart’ (data not shown). The only statistically significant difference between treated cherries and untreated controls was observed for ‘Liberty Bell’ in which cracking was significantly reduced by the formulation.

In summary, a number of promising experiments were completed during 2002. Several of these need to be confirmed and expanded in the future. A new proposal has been submitted requesting funding for two additional years to study the formulation for suppression of cherry cracking and post-harvest stem browning and water loss.
**Fig. 1.** Air temperature versus cherry fruit surface temperature on sun-exposed side. Lower line is air temperature and upper line is fruit surface temperature.

**Fig. 2.** Effect of water temperature on cracking of ‘Bing’ cherries immersed in water.
Fig. 3. Effect of water quality on ‘Bing’ cherry cracking. DW = deionized water; CW = city water; IW = irrigation water; SS = 10% (w/v) sucrose solution.

Fig. 4. Effect of water quality on water absorption by ‘Bing’ cherries. DW = deionized water; CW = city water; SS = 10% (w/v) sucrose solution.
Effect of Matrix on Cherry Water Absorption
(Bing, in Laboratory on July 1, 2002)

Effect of Matrix on Cherry Fruit Cracking
(Bing, in Laboratory on July 1, 2002)

Fig. 5. Effect of Formulation II (10 and 20%) on water absorption by ‘Bing’ cherries

Fig. 6. Suppression of ‘Bing’ cherry cracking when formulation II was applied at 10 and 20% [10% M and 20% M] vs. control (CK).
Cracking of Bing stem bowl in matrix vs. control at 30 and 45ºC, July 8, 2002

Fig. 7. Effect of formulation and temperature on cracking of 'Bing' cherries at the stem bowl.

Cracking of Rainier stem bowl in matrix vs. control at 30 and 45ºC, 7.08.02

Fig. 8. Effect of formulation and temperature on cracking of 'Rainier' cherries at the stem bowl.
Fig. 9. Suppression of cracking of ‘Bing’ cherries with two formulations applied to cherries in the field.

Fig. 10. Effect of formulation on water loss from harvested ‘Sweetheart’ cherries at room temperature. Cherries with and without the pedicel (stem) were compared.
Budget:

Title: New tactic for suppressing cracking of cherries

PI: Larry Schrader

Project duration: 1 year

Current year: 2002

Project total: $16,780 for 1 year (2002)

Current budget request: See new project proposal.

<table>
<thead>
<tr>
<th>Year</th>
<th>Year 1 (2002)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>$16,780</td>
</tr>
</tbody>
</table>

Current year breakdown

<table>
<thead>
<tr>
<th>Item</th>
<th>Year 1 (2002)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries¹</td>
<td>$ 9,087</td>
</tr>
<tr>
<td>Benefits (27%)</td>
<td>2,453</td>
</tr>
<tr>
<td>Wages²</td>
<td>1,500</td>
</tr>
<tr>
<td>Benefits (16%)</td>
<td>240</td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>Supplies³</td>
<td>3,000</td>
</tr>
<tr>
<td>Travel⁴</td>
<td>500</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$16,780</td>
</tr>
</tbody>
</table>

¹Salary requested for an agricultural research technologist II (25% time) for Schrader. A budget reduction at WSU in 2001 reduced technical support for Schrader to 0.75 FTE.

²Time-slip help for Whiting.

³Supplies include pumps to be used in “rain simulation” tests, sprinkler heads etc. for overhead application of water, mylar bags to enclose trees, and other general supplies.

⁴Travel to experimental plots.

Summary of total cost for final report: $16,780