**FINAL PROJECT REPORT**
**WTFRC Project Number:**


**Project Title:** Improving Cherry Fruit Quality and Postharvest Shelf Life
**PI:** Larry Schrader
**Organization:** WSU Tree Fruit Research and Extension Center
**Address:** 1100 N. Western Avenue
**City/State/Zip:** Wenatchee, WA 98801

**Cooperators:** Jizhong Xu and Cindy Kahn
WSU Tree Fruit Research and Extension Center, Wenatchee, WA 98801


**Budget History:**

| Item | Year 1: 2005 | Year 2: 2006 |
|---|---|---|
| **Salaries** | 10,608 | 11,032 |
| **Benefits** | 4,031 | 4,192 |
| **Wages** | 2,000 | 2,000 |
| | | |
| **Benefits** | 320 | 220 |
| **Equipment** | | |
| **Supplies** | 3,000 | 3,000 |
| **Travel** | 500 | 500 |
| | | |
| **Miscellaneous** | | |
| **Total** | 20,459 | 20,944 |

**Objectives:**

1. Investigate the effects of formulations on stem browning and water loss of cherries after harvest.
2. Compare water loss in stem-free cherries to water loss in cherries with stems.
3. Apply gibberellic acid at different stages of maturity and study its effect on fruit quality.
4. Study efficacy of GA when tank mixed and applied with RainGard.
5. Conduct microscopic studies to determine anatomical differences among cultivars that differ in their susceptibility to rain cracking.
6. Conduct further studies to improve efficacy of RainGard, cherry cracking suppressant.

**Significant findings:**

1. Water loss in stem-free cherries during cold storage was reduced by the following dip treatments: 20 ppm $GA_3$, 5% RainGard, and 20 ppm $GA_3$ + 5% RainGard for 10 seconds after harvest. The most effective treatments were 5% RainGard and 20 ppm $GA_3$ + 5% RainGard.
2. Water absorption by cherries dipped postharvest in RainGard alone or RainGard + GA was also reduced significantly as compared to controls or GA alone.
3. Quality factors such as firmness, soluble solids content, and water loss in stem-free cherries was not significantly different from cherries with stems during cold storage.
4. Cracking in Bing cherries was decreased by 47%, on average, with four weekly applications of RainGard in three orchards in The Dalles, Oregon, during 2005.
5. Cracking in Rainier was more severe than in Bing, and RainGard was less effective in suppressing cracking of the Rainier cherries. The suture of Rainier appears to be very susceptible to cracking.
6. For Sweetheart, four RainGard applications at weekly intervals during 2005 decreased cracking by 38%.
7. With Tieton, four RainGard applications during 2005 decreased cracking by 35%.
8. Based on many studies, a program that includes four weekly applications of RainGard prior to harvest is recommended for best protection of sweet cherries from rain cracking.

**Materials and Methods:**

***Objectives 1 and 2:*** Stem-free Bing cherries were harvested on June 26, 2006, from trees treated with 550 ppm Ethephon at one and two weeks before harvest. The method for harvesting stem-free cherries consisted of shaking tree limbs and catching cherries on a raised plastic tarp. For each replication, 25 cherries of uniform quality were placed in plastic clamshells. Cherry firmness was measured weekly with a FirmTech 2 fruit firmness tester (Bio Works, Inc. U.S.A.). Cherries were removed from cold storage and warmed to room temperature two hours prior to testing. Water loss was determined by weighing the cherries weekly. Water loss was calculated with the following formula: (W1-W2)/W1. W1 = initial weight and W2 = final weight. Soluble solids content was measured weekly with a digital refractometer, and results were expressed in degrees Brix.

***Objectives 3 and 4:*** Initial experiments to test efficacy were done during 2005 on single trees in a two-way factorial randomized complete block with four replications. GA was applied alone at different concentrations and also tank mixed with RainGard before application. Applications were sprayed on cherries at different intervals prior to maturity.

In 2006, stem-free cherries at room temperature were dipped in different solutions for 10 seconds after harvest. Treatments included water, 20 ppm $GA_3$, 5% RainGard, and 20 ppm $GA_3$ + 5% RainGard. A control with no treatment was also included. Treatments of 20 ppm $GA_3$ + 5% RainGard

were done for 30 and 60 seconds. Treatments contained four replicates of 25 fruit each. The fruit were placed in cold storage and evaluated for quality and water loss.

**Water absorption**: Cherries were weighed prior to treatments, dipped in the various treatments for different amounts of time and then blotted dry with paper towels. Cherries were weighed again when they were dry. Water absorption was expressed by the difference in cherry fruit weights (weight of 25 cherries after treatment minus weight of cherries before treatment).

**Fruit firmness**: Cherry firmness was measured weekly with a FirmTech 2 fruit firmness tester (Bio Works, Inc. U.S.A.). Cherries were removed from cold storage and warmed to room temperature two hours prior to testing.

**Water loss in storage**: The cherries were weighed weekly. The water loss rate was calculated with the following formula: W1-W2)/W1. W1 =initial weight and W2 = final weight.

**Soluble solids content (SSC):** SSC was measured weekly with a digital refractometer, and results were expressed in degrees Brix.

***Objective 5:*** Digital images were taken with a Nikon SMZ-U dissecting microscope to observe differences in the structure of the stylar scar end of each of several cultivars.

***Objective 6:*** In 2005, 13 grower/cooperators were selected for efficacy testing of RainGard, a new experimental product to protect cherries from cracking. Locations of these test sites varied widely from Kennewick and Pasco, Washington, on the east to Tonasket, Washington, on the north and to The Dalles, Oregon, on the west. Sufficient rain to cause measurable cracking occurred at only six sites. The predominant cultivar studied was Bing although at least one of the trials included Staccato, Sweetheart, Rainier or Tieton. Quality data (fruit weight, color, firmness, soluble solids and titratable acidity) were collected on fruit from 10 of the 13 trials.

All treatments were applied by grower/cooperators. The four treatments for every trial were as follows:

A. 10% (v/v) RainGard, two applications—at straw color of fruit (or slightly earlier if rain were imminent) and two weeks after the first application;
B. 5% (v/v) RainGard, two applications with same timing of applications as with treatment A;
C. 5% (v/v) RainGard, four weekly applications—first application same as above, and then weekly thereafter;
D. Untreated control (i.e., no application of RainGard).

**Results and discussion:**

***Objectives 1 and 2*:** In cold storage, water loss in 2005 in stem-free Sweetheart cherries as well as stemmed cherries was reduced significantly when cherries were dipped into RainGard for 10 seconds immediately after harvest (data not shown).

**Water loss studies in 2006**: The weekly changes in cherry water loss during cold storage are shown (Fig. 1). The water loss of the stem-free fruit was slightly higher than that of fruit with stems during cold storage, but differences were not statistically significant. At 8 weeks after harvest (WAH), the total water loss was 5.52% for the stem-free cherries and 5.05% for the stemmed fruits.

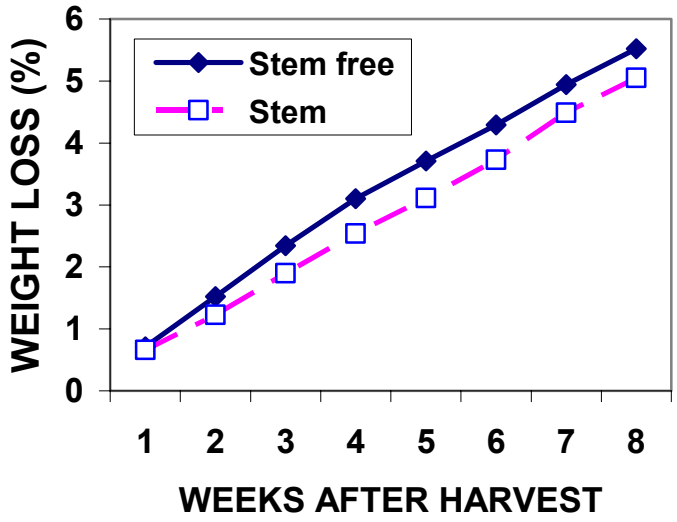


Figure 1. Cumulative water loss from stem-free and normal cherries during cold storage.

**Fruit firmness**: Changes in firmness during cold storage were similar between stem-free cherries and cherries with stems. The firmness of cherries with stems increased at 5 WAH, while the stem-free cherries began to decrease in firmness (Fig. 2). Firmness of fruit with stems was higher than that of stem-free fruit during cold storage, but differences between the two types of fruit were not statistically significant. Firmness of the stem-free fruit was 218.5 g/mm at harvest and 223.7 g/mm for the fruit with stems. The firmness of the cherry fruit usually increased from 1 WAH to 5 WAH (for stem-free fruit) and from 2 WAH to 6 WAH (for fruit with stems) during cold storage. The firmness of the stemmed fruits was 253.4 g/mm at 6 WAH, which was an increase of 13.3% from the firmness at harvest. Firmness was the highest (237.6 g/mm) at 5 WAH for the stem-free fruit, an increase of 8.7% from harvest. These observed increases in firmness during cold storage were not expected but may be attributable to loss of water during storage.

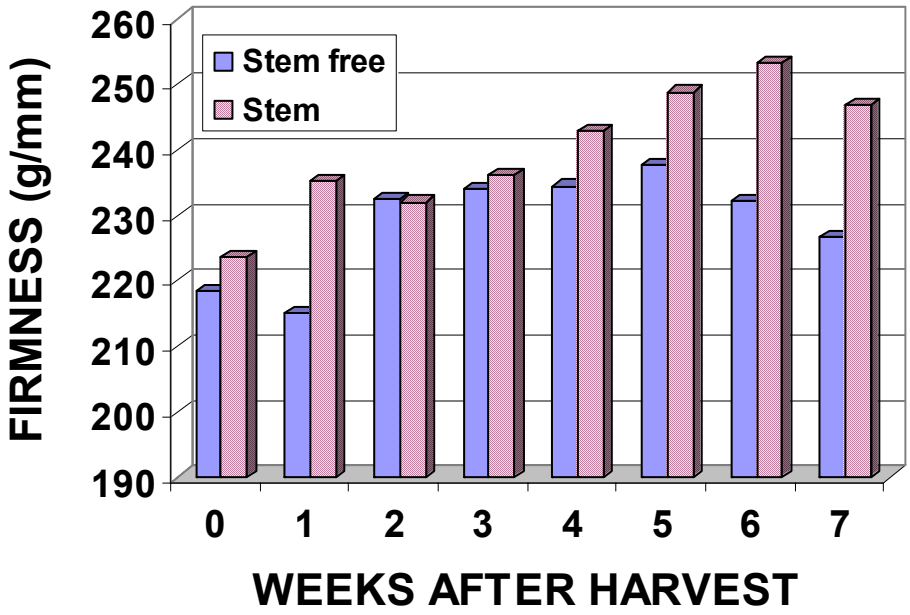


Figure 2. Cherry firmness during cold storage.

**Soluble solid content (SSC):** SSC was 16.7% for fruit with stems and 16.9% for the stem-free fruit at harvest, respectively. The SSC in the fruit with stems was lower than that of the stem-free fruit, but differences were not significant statistically (Fig. 3).

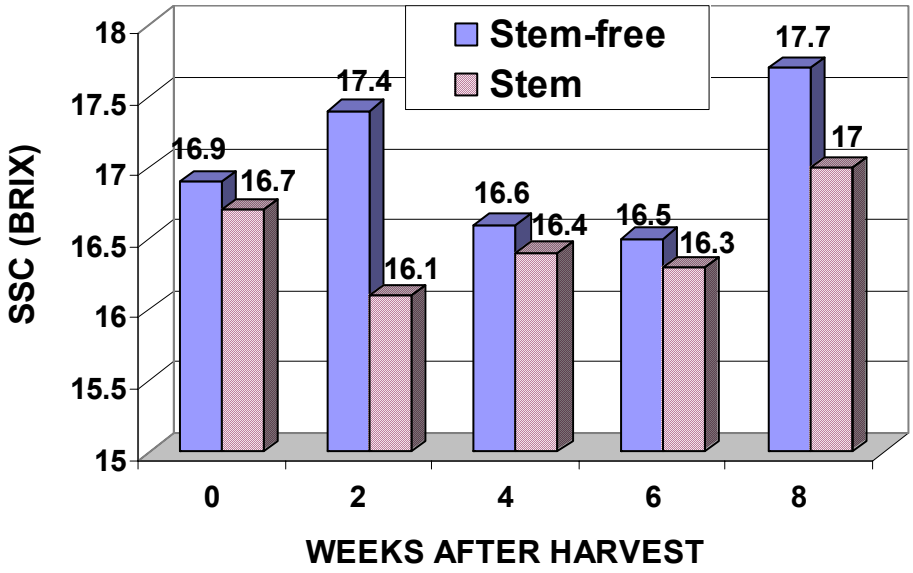


Figure 3. Soluble solids content (SSC) of stem-free cherries and cherries with stems.

***Objectives 3 and 4*:** In 2005, GA, RainGard alone, and RainGard + GA were applied by spraying on Rainier and Bing at various intervals prior to harvest to determine if GA and RainGard can be applied

together. No significant differences were observed among the treatments for SSC, fruit weight, firmness, titratable acidity or color.

**Postharvest water absorption**: In 2006, cherry water absorption was influenced by the type of treatment applied to the cherries postharvest. The $GA_3$, RainGard + $GA_3$, and RainGard only treatments significantly reduced the amount of water absorbed compared to the untreated control ($P<0.01$) (Fig. 4). Water absorption for cherries treated with water, $GA_3$, RainGard, and $GA_3$ + RainGard were 4.54, 3.26, 1.64, and 1.07 g/unit, respectively (one unit=25 cherries).

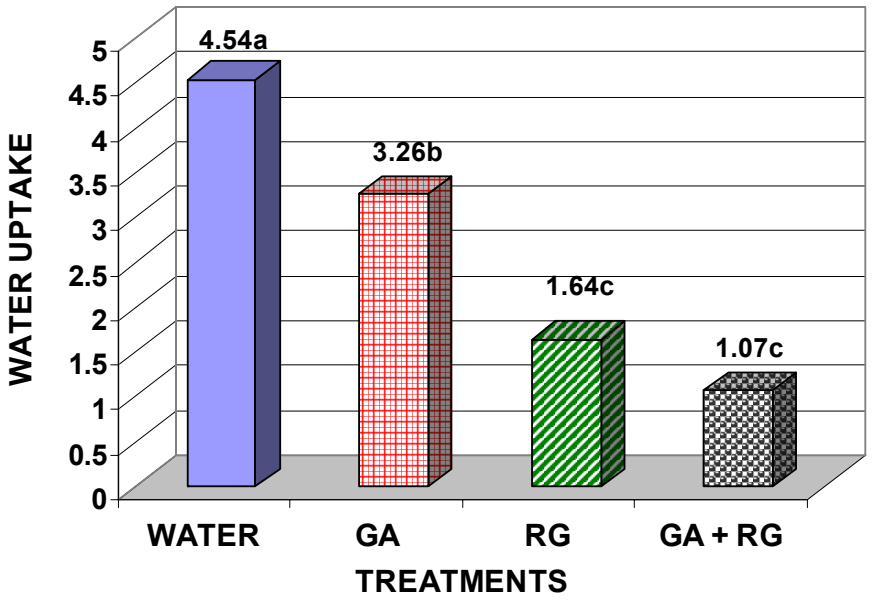


Figure 4. Water absorption after 30 minutes by cherries treated for only 10 seconds with different formulations. Water (undipped control), GA=$GA_3$, RG=RainGard, GA + RG=$GA_3$+RainGard. Bars with different letters after the values above the bars are significantly different ($P<0.01$).

**Postharvest water loss**: Cherry water loss during cold storage was examined weekly. The $GA_3$, RainGard, water treatment, and $GA_3$+RainGard treatments significantly reduced water loss at one week after treatment (WAT) as compared to the untreated control cherries (for water treatment $P<0.05$ and all other treatments $P<0.01$). Water loss in cherries treated with water, $GA_3$, RainGard, and $GA_3$+RainGard at 1 WAT was 0 .55%, 0.20%, 0.14%, and 0.21%, respectively, while the untreated control cherries had a water loss of 0.82% (data not shown). Water loss gradually increased during cold storage (Fig. 5). Cumulative water losses from cherries treated with RainGard and $GA_3$+RainGard were the lowest of all treatments during six weeks of cold storage and were significantly lower than that of the untreated control ($P<0.01$ between 2 and 4 WAT, or $P<0.05$ at 6 WAT). Cumulative water loss from cherries treated with $GA_3$ was significantly lower than that of the control ($P<0.01$ at 4 WAT or $P<0.05$ at 2 and 6 WAT). Cumulative water loss of cherries treated with water, $GA_3$, RainGard, and $GA_3$+RainGard were 3.52%, 3.13%, 3.12%, and 3.09%, respectively, at 6 WAT and 3.93% for the untreated control cherries. Firmness and SSC were not significantly affected by these treatments. We conclude that postharvest applications of RainGard alone or RainGard + GA are effective in reducing water absorption postharvest and also water loss of cherries during cold storage.

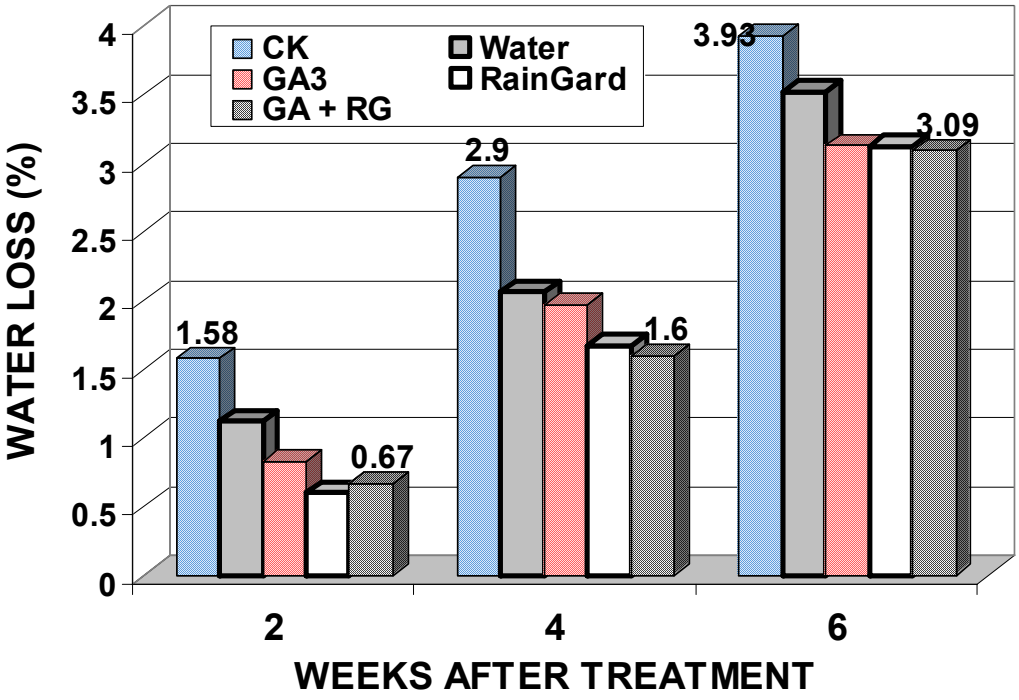


Figure 5. Cumulative water loss in cherries treated with different formulations (GA + RG=$GA_3$+RainGard; CK= untreated control; Water=cherries treated with water only).

***Objective 5*:** We previously observed that the junction between the stylar scar tissue and the cuticle appears to be open in Bing cherries, partially open in Van and closed in Lapins. "Conductive" tissue appears to be more pronounced in Bing, somewhat less in Van and even less apparent in Lapins. Tieton's anatomy seems similar to Bing and may account for its susceptibility to cracking. Rainier cherries were also examined in this manner but showed a tight junction between the stylar scar and the cuticle. However, we have observed that the suture of Rainier cherries is especially susceptible to cracking, but this needs more examination.

***Objective 6:*** To test efficacy, RainGard was applied to Bing cherries in three orchards near The Dalles, Oregon, during 2005. These trials were funded by other extramural funding. The mean of all three trials is shown (Fig. 6). Total cracking in all three RainGard treatments was significantly lower than in the untreated control (D). Treatment C (four weekly applications) had significantly less cracking than the other three treatments.

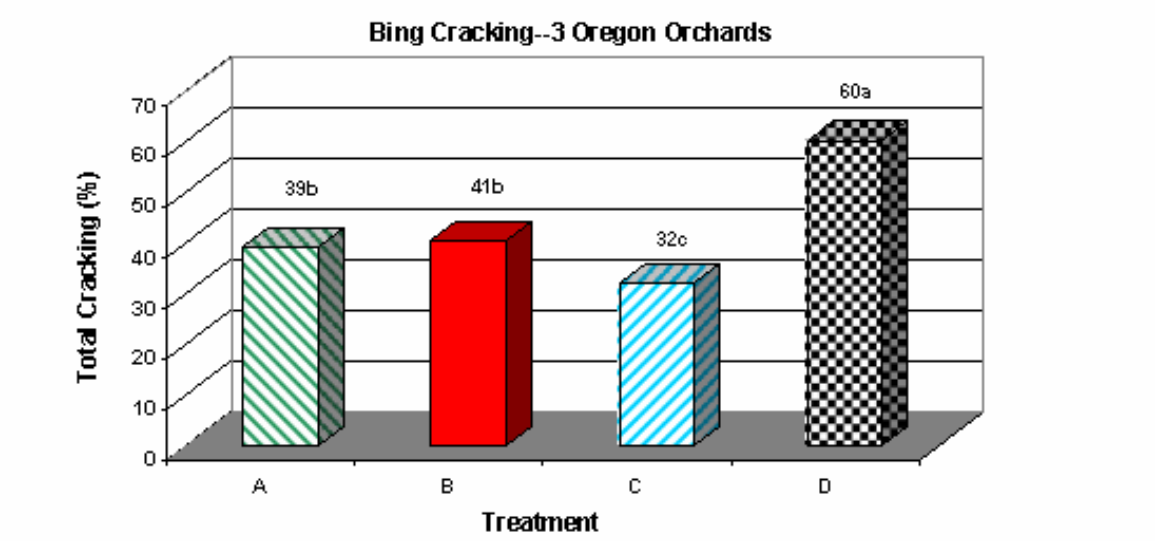


Figure 6. Total cracking of Bing cherries averaged from three orchards near The Dalles, Oregon. Three RainGard treatments are compared to the untreated control (Treatment D). See methods for description of RainGard treatments. If the number above a bar within the graph is followed by a letter different from that above another bar, that bar is significantly different (P<0.05) than the other.

Rainier and Bing were compared in one Oregon orchard, and total cracking was significantly higher in Rainier than in Bing with all four treatments (Fig. 7). With Bing and Rainier, all RainGard treatments significantly decreased cracking as compared to the untreated control (D). Cracking in Bing was lowest again in Treatment C (four weekly applications).

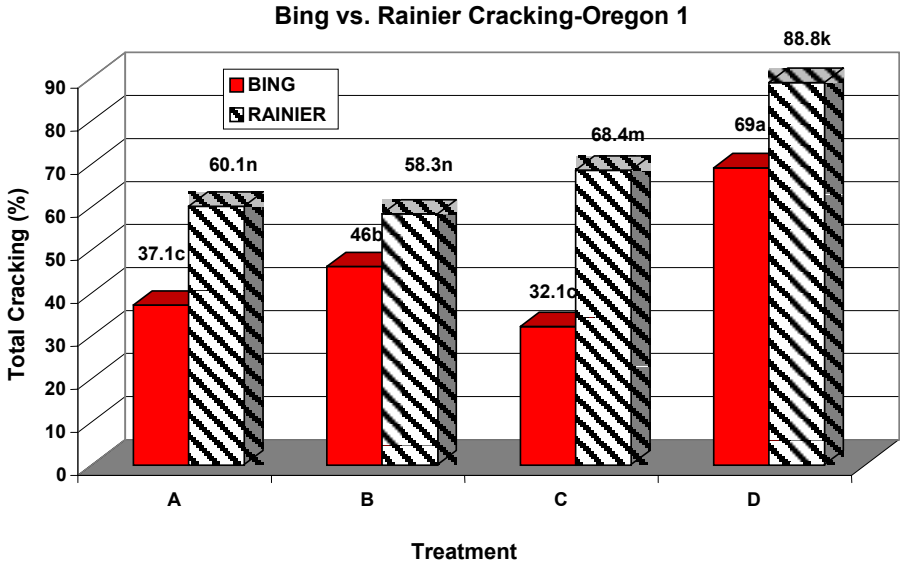


Figure 7. Comparison of cracking in Bing and Rainier sweet cherries in an Oregon orchard with three RainGard treatments versus an untreated control (D).

With Sweetheart cherries, cracking was significantly lower in Treatment C as compared to other treatments (Fig. 8). With Tieton cherries, cracking was also significantly lower in Treatment C as compared to all other treatments (Fig. 9).

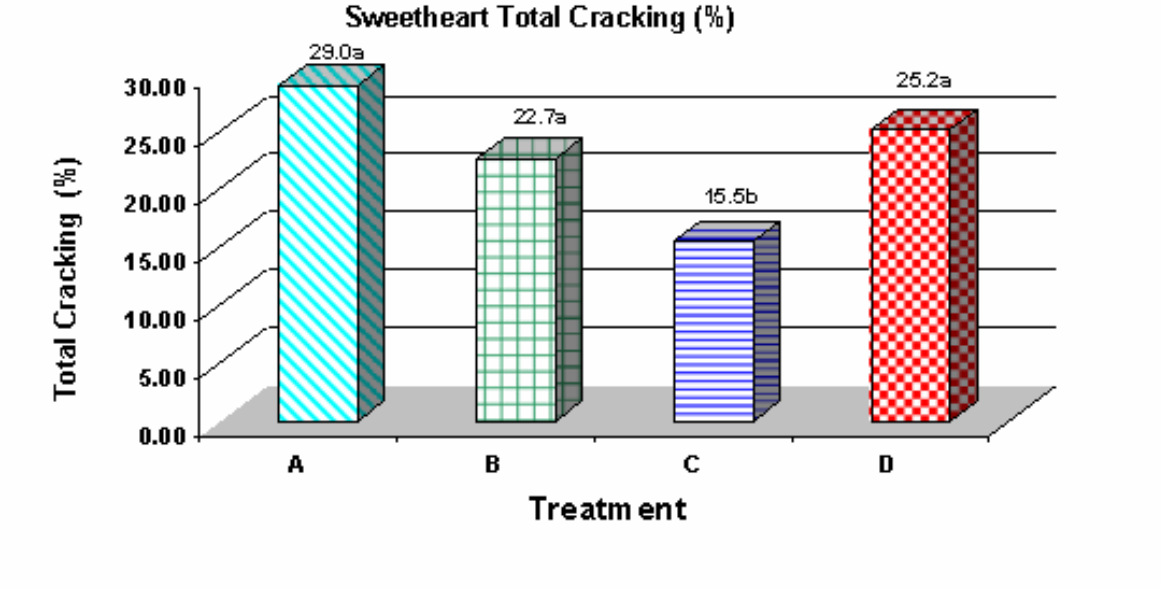


Figure 8. Total cracking of Sweetheart cherries treated with three RainGard treatments versus an untreated control (D).

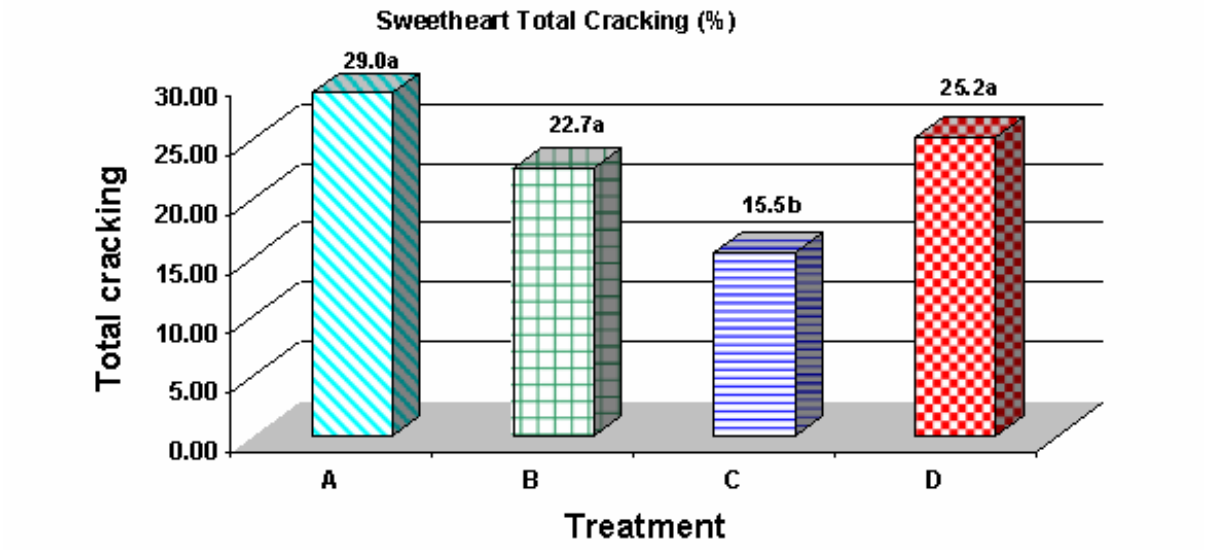


Figure 9. Total cracking of Tieton cherries treated with three RainGard treatments versus an untreated control (D).

The results in Figs. 5 to 9 indicate that more frequent applications (Treatment C—four applications at weekly intervals) provided better protection from rain. The surface area of the cherry expands rapidly during the last few weeks of development and within a few days causes the protective film on the

cherry to become less effective in protecting from the rain (Fig. 10). Note the rapid increases in fruit surface area during the four weeks before harvest. Weekly RainGard applications maintain the protective film for better protection from rain.

The quality analyses completed on 10 trials showed no appreciable differences among the treatments in any cultivar. This included fruit size, color, titratable acidity, soluble solids and firmness.

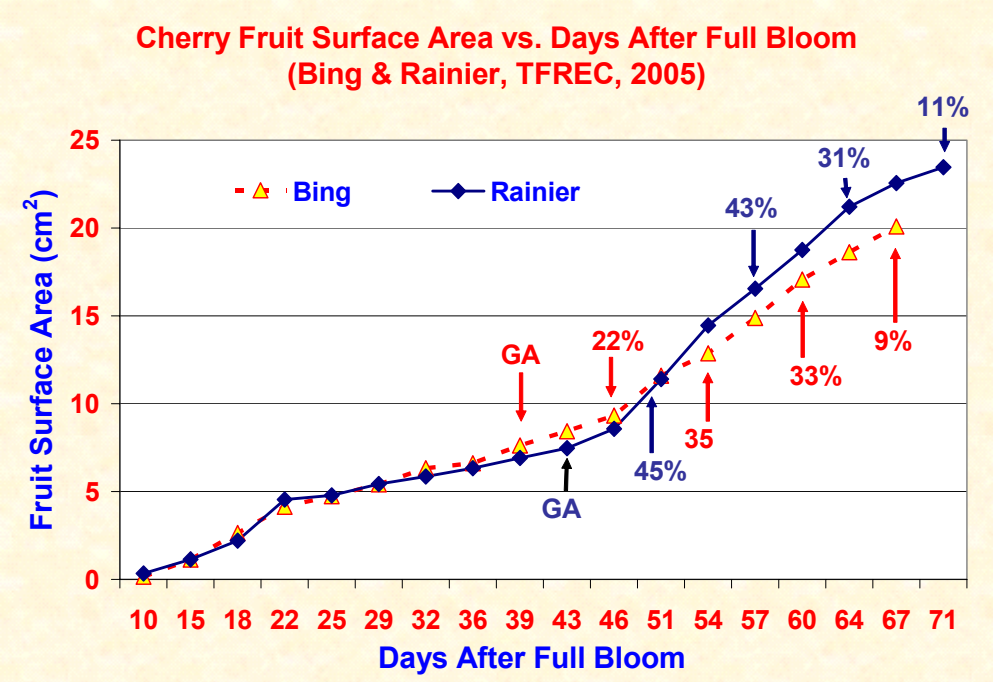


Figure 10. Growth curves for Bing and Rainier cherries. Fruit diameter was determined twice weekly, and then fruit surface areas were calculated.

**SIGNIFICANCE OF RESEARCH TO SWEET CHERRY INDUSTRY:**
The research conducted under this project has shown that stem-free cherries maintain their firmness and other quality factors during cold storage as well as cherries with stems. Water loss after harvest can be decreased by dipping the cherries in RainGard or RainGard + GA for several seconds. As our research revealed more about the causes of rain cracking of sweet cherries, a protectant called RainGard™ was developed and made available to growers on a limited basis during 2006. RainGard is the most effective protectant available to cherry growers at this time.

NOTE: WSU is including the following information on other funding available for the support of similar research undertaken by the faculty member proposing this research. These resources are listed to identify other support granted for this research and are not included as a commitment of cost-share by the institution.
OTHER FUNDING: FruitGard LLC and Pace International LLC provided over $21,000 for Objective 6 (efficacy testing of RainGard) during 2005 and over $9,000 during 2006.