FINAL REPORT

WTFRC Project #AH-03-305 **WSU Project #13C-3655-5326**

Project title: Suppressing cherry cracking and post harvest stem browning and water loss

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Objectives:

1. Determine efficacy of spraying a new hydrophobic/lipophilic formulation to suppress cracking of cherries.
2. Optimize timing and rate of application of the new formulation.
3. Investigate fruit cracking with electron and low magnification microscopy to observe formulation effects on cherry cuticle and differences in conductive tissue morphology in various cherry cultivars.
4. Determine whether fruit quality and appearance are altered by the formulation.
5. Determine efficacy of the new formulation for decreasing water loss from harvested cherries and for retention of green stems on cherries after harvest.

Significant findings:

1. A new improved formulation (RainGard, patent pending) suppressed cherry cracking in orchard trials where significant rain occurred during the 2004 growing season. Cracking in 'Bing' cherries was decreased as much as 62% in one Oregon orchard (Fig. 1). Cracking suppression in field trials was comparable to controlled studies conducted earlier in our lab and research orchard.
2. In four trials on 'Rainier' cherries, cracking was decreased significantly ($P<0.05$) in three trials with one or two applications of RainGard (Fig. 2).
3. Even though the first RainGard application was done three weeks before maturity at "straw" color, cracking had already occurred in some orchards. Thus, the first application should have been made earlier in 2004, as cracking occurred as early as four weeks before maturity.
4. In some trials, the first application was as effective as two because no rain occurred after the first application.
5. RainGard caused a significant reduction in cracking of 'Sweetheart' cherries in the lower canopy where irrigation water caused severe cracking. RainGard was significantly better than Vapor Gard or the untreated control (Fig. 3).

6. With ‘Rainier’ cherries, timing of applications was important. An application at one week before maturity (hours before a rain) was significantly better than an application made three weeks before maturity. These single treatments and a combined treatment (at three weeks and one week before maturity) were all significantly better than the untreated control (Fig. 4).
7. Dr. Brown studied efficacy of RainGard in Tasmania, Australia, in late 2003. Arrival of the formulation was delayed by Customs in Sydney so cracking had occurred prior to the first application. However, cracking was reduced in ‘Bing’ and ‘Van’ by one and two applications of RainGard (Table 1) as compared to the control.
8. Using electron microscopy, Dr. Curry compared untreated cherries to cherries treated with 10% (v/v) formulation as well as calcium chloride (Figs. 5 and 6). His micrographs showed a nice coating of the cherries with the formulation without affecting stoma opening (Fig. 6).
9. Microscopic studies done at lower magnification in our lab showed cultivar differences in conductive tissue morphology, especially at the stylar scar. Open channels were observed in cultivars that were more prone to cracking when compared to cultivars that are more resistant to cracking.
10. Fruit quality (e.g., weight, firmness, color and brix) was not changed significantly by preharvest applications of RainGard during 2004. No negative effects on fruit quality or size were observed with RainGard.
11. Although promising results were observed in previous years, green stem retention and moisture loss were not significantly changed by one or two preharvest applications of RainGard in 2004. All fruit maintained in cold storage retained green stem freshness for three weeks but deteriorated quickly as the fruit warmed to room temperature.
12. Stem browning occurred first at the end of the pedicel and progressed toward the cherry as time at room temperature elapsed.

Methods:

Objective 1: The formulation was applied on cherry trees of several cultivars in commercial orchards in central Washington and northern Oregon by spray application at a rate of 10 gallons of formulation per acre. Four uniform blocks of approximately 0.75 acres were selected for three treatments and a control. The protocol called for the formulation to be applied three weeks before harvest in treatment A, one week before harvest in treatment B, and three weeks and one week before harvest (two applications) in treatment C. Treatment D was an untreated control. The three-week application was designed to occur at the “straw color” when cherries were first thought to be susceptible to rain-induced cracking. Growers were advised to use normal practices (e.g., airblast sprayer, helicopter, calcium spray, etc.) to protect their cherries in the event of rain as long as all blocks were treated the same. Growers contacted us if they experienced rain-induced cracking. At sites where cracking was present, four trees were randomly selected for evaluation from each treatment protocol and affected cultivar. All of the fruit from a single limb in the southwest canopy of the selected trees was harvested, and the number of cracked vs. non-cracked fruit and the type of cracking (stem bowl, stylar end, shoulder, suture, other) was recorded for comparison to the control blocks. Data were analyzed statistically.

Objective 2: Cracking frequencies for each treatment were compared to determine when and how often the formulation should be applied. In northern Oregon, rain-induced cracking occurred in some orchards before the first application was made. Rain-induced cracking occurred at only one experimental site in central Washington, but cracking was observed in one orchard due to irrigation water exposure.

Objective 3: Previously submitted reports outline methods used to study formulation effects on the cherry cuticle and morphological differences as seen in microscopic examinations**.**

Objective 4: At harvest, maturity samples were collected from each of the trials. Four trees were selected from each treatment. Five 2-lb clamshells were filled with cherries from each of the selected trees. All fruit was stored at 33°F within four hours of harvest. The following day, sample lots of 25 cherries from each replication were allowed to warm to room temperature before testing for size and firmness with a FirmTech 2. The cherries were then evaluated for color using the CTIFL cherry color comparators (1-6 scale). Finally, the juice expressed from each lot of 25 cherries was tested for brix using a digital refractometer. These tests were repeated at weekly intervals for three weeks post harvest.

Objective 5: Cherries from each of the previously described samples were also used to assess green stem freshness by assigning a value for the stem color from 1-4 based on the amount of browning present (1=25% browning, 2=50% browning, 3=75% browning, and 4 =100% browning). A weighted average for the frequency of observations in each category gave a relative comparison of the effectiveness of each treatment. These assessments were done on cherries at room temperature. Moisture loss was determined by comparing the initial post harvest weights of cherries in two clamshells with the weights of those same cherries at three weeks post harvest.

Results and discussion:

During 2004, the improved formulation, RainGard, was tested in 11 orchards in Oregon and Washington. Rain induced cracking in 'Bing' cherries at four orchards near The Dalles and Hood River, OR. Cracking was reduced by one or two applications of RainGard in all four trials (Fig. 1) and was significantly different ($P<0.05$) than the untreated control in orchards 1 and 2. In orchard 4, RainGard was significantly different ($P<0.10$) than the untreated control. Some cracking had occurred in orchards 3 and 4 prior to the first application of RainGard so these efficacy data were compromised. Due to a misunderstanding, the spray applicator made two applications to all cherries except the controls in orchard 1. In the other trials the results shown in Fig. 1 compare treatment A (applied three weeks before maturity) with the untreated control, as there was little change in cracking between treatments A, B, and C.

In 'Rainier' cherries, two applications of RainGard significantly reduced cracking ($P<0.05$) in orchards 1 and 2 in Oregon and in orchard 4 in Washington (Fig. 2). In orchard 3, RainGard was significantly better ($P<0.10$) than the control. Cracking in 'Rainier'cherries was predominantly in the suture of the fruit, whereas cracking in other cultivars was predominantly at the stylar end or around the stem bowl (data not shown).

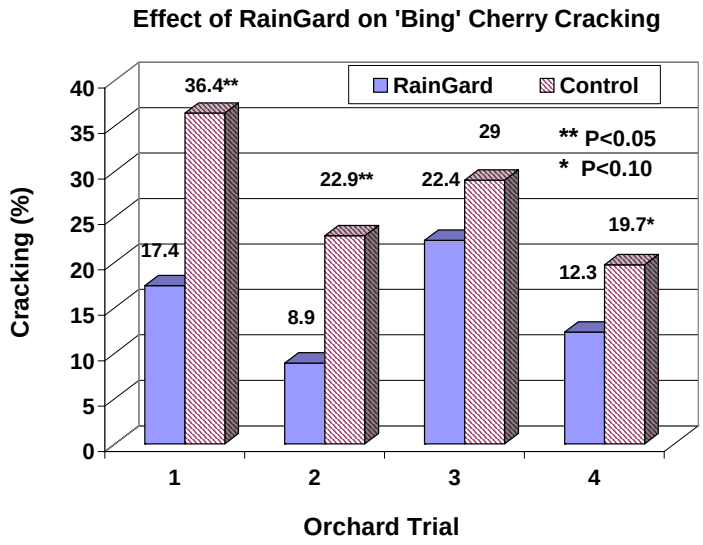

Fig. 1. Efficacy of RainGard for protecting 'Bing' cherries from cracking in four Oregon orchards. Rain caused cracking in all four orchards. RainGard was applied by growers at approximately three weeks and one week before maturity, but the results for only the three-week treatment and controls are shown for orchards 2 through 4.

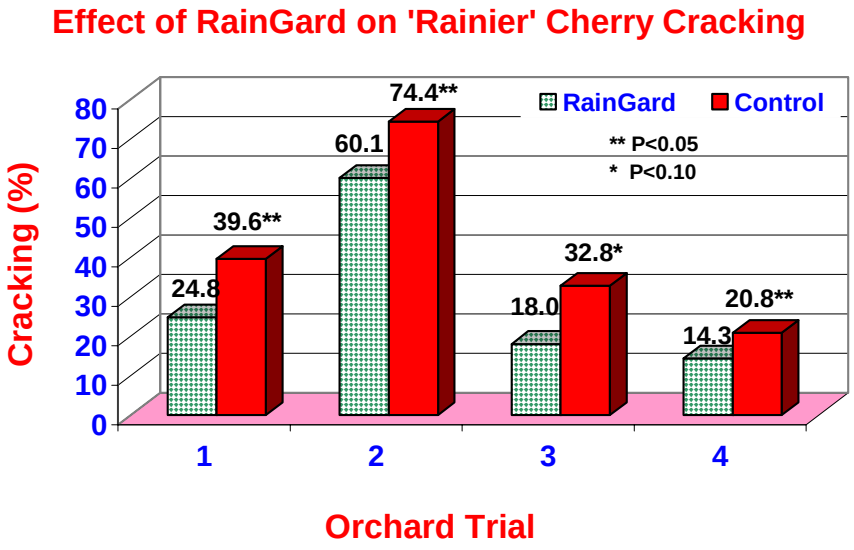

Fig. 2. Efficacy of RainGard for protecting 'Rainier' cherries from cracking in three Oregon and one Washington orchard. Rain caused cracking in all orchards. RainGard was applied by growers at three weeks and one week before maturity.

In another trial near Brewster, WA, two applications of RainGard reduced cracking in 'Sweetheart' cherries in both the upper and lower canopy. Undertree irrigation caused a high level of cracking in the lower canopy, and RainGard significantly ($P<0.05$) reduced cracking as compared to the untreated control or cherries treated with two applications of Vapor Gard (Fig. 3).

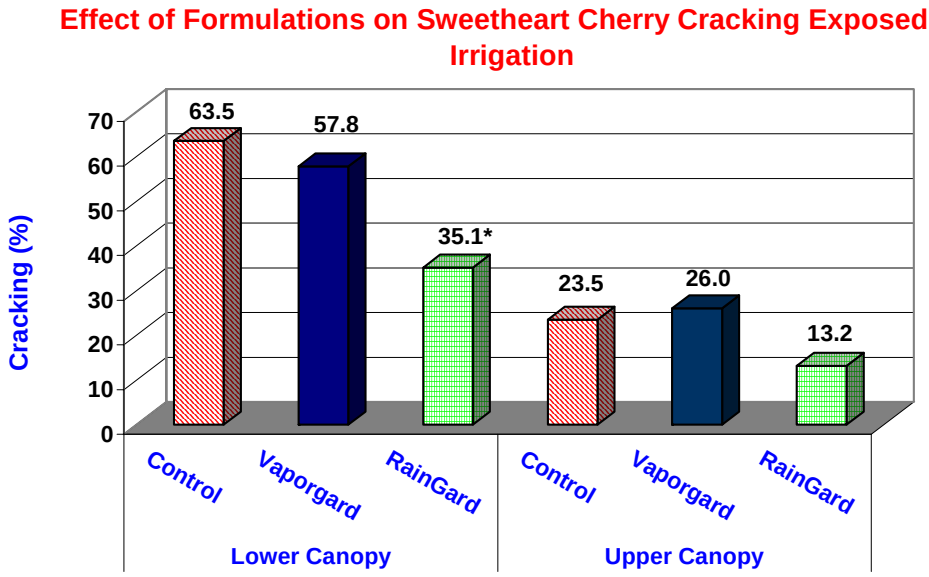

Fig. 3. Efficacy of Vapor Gard and RainGard for protecting 'Sweetheart' cherries from cracking. RainGard was applied by grower at three weeks and one week before maturity. Vapor Gard was also applied twice. Undertree irrigation caused substantial cracking of cherries in the lower canopy.

In a timing study involving 'Rainier' cherries, cracking in treatments A, B, and C was significantly lower ($P<0.05$) than in the untreated control (Fig. 4, treatment D). Treatment B was significantly better than treatment A. Rain occurred within hours after the second application was made (Fig. 4, treatments B and C). Optimal timing of applications is therefore dependent on when rain occurs at that site. Maximal protection from cracking is dependent on maintaining an effective film on the fruit, as fruit surface area doubles (100% increase) each time the fruit diameter increases by only 40%. For example, a cherry that is 0.33 inches in diameter increases in surface area by 300% by the time it reaches a diameter of 0.91 inches. That cherry increases in surface area by 400% if its diameter reaches 1.28 inches by maturity. Therefore, a single application three or four weeks before maturity is not sufficient to provide an effective rain-repelling film until maturity. Two or three applications may be needed to protect the fruit until maturity.

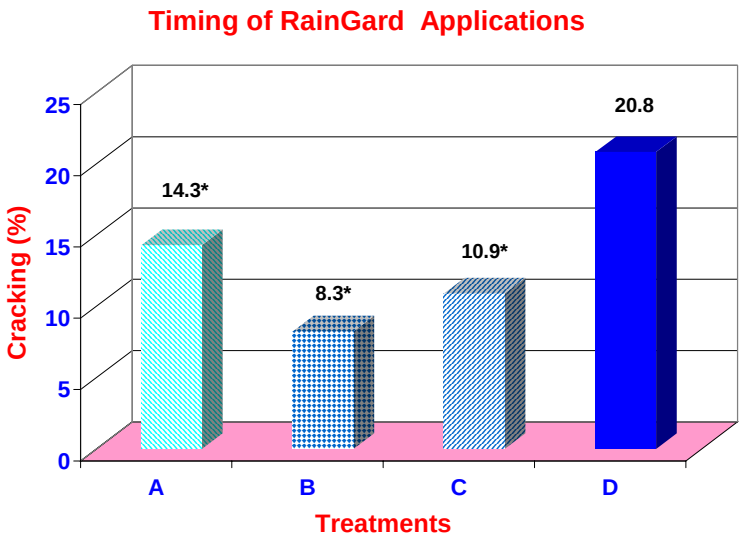

Fig. 4. Effect of timing of RainGard applications on cherry cracking in 'Rainier' cherries (treatment A=one application at three weeks before maturity; treatment B=one application at one week before maturity; treatment C=two applications (three weeks and one week before maturity; treatment D=untreated control).

Dr. Gordon Brown, our cooperator in Tasmania, Australia, also conducted experiments during late 2003. Unfortunately, the formulation was quarantined in Sydney, Australia for at least two weeks so Dr. Brown was unable to apply the formulation as early as desired. Substantial cracking had occurred before his first application. In spite of that, the formulation applied two weeks before harvest (2 wbh) or one week before harvest (1 wbh) had more intact cherries (i.e., less cracking) than the untreated controls (that had rain blown off three times by helicopters). The differences were not statistically different at $P<0.05$.

Table 1. Percent intact 'Bing' or 'Van' cherries in study comparing RainGard with Vapor Gard in Tasmania, Australia. Applications were made one (1wbh) or two weeks (2wbh) before harvest. Study was conducted by Gordon Brown and colleagues in Tasmania.

Treatment	% Intact Bing	% Intact Van
Untreated	75.20	82.00
2 wbh	84.98	85.75
1 + 2wbh	79.58	84.50
1 wbh	84.38	82.50
Vapor Gard	77.73	87.50

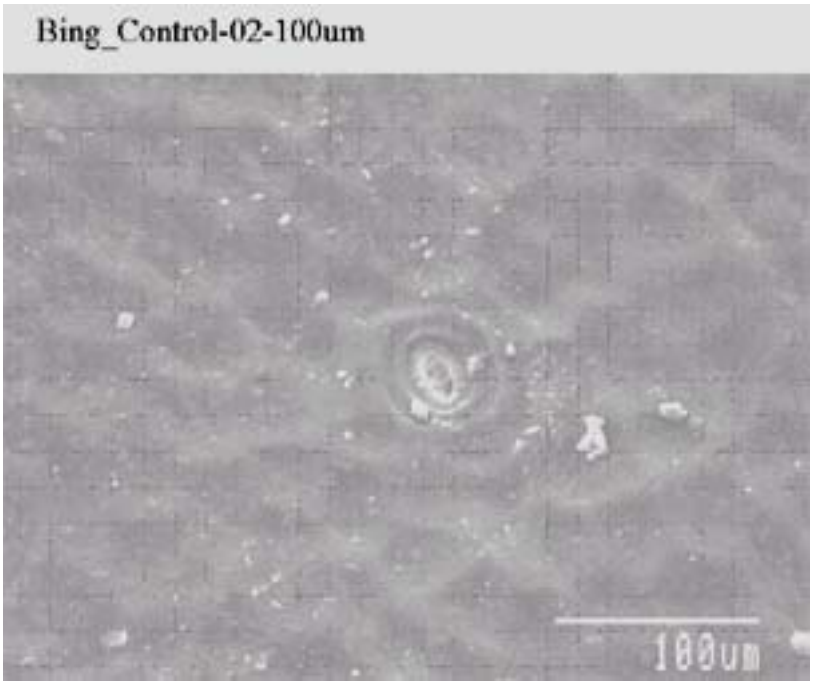

Fig. 5. Electron micrograph of the cuticle of an untreated ‘Bing’ cherry (provided by Dr. Eric Curry). Note the open stoma near the center of the micrograph.

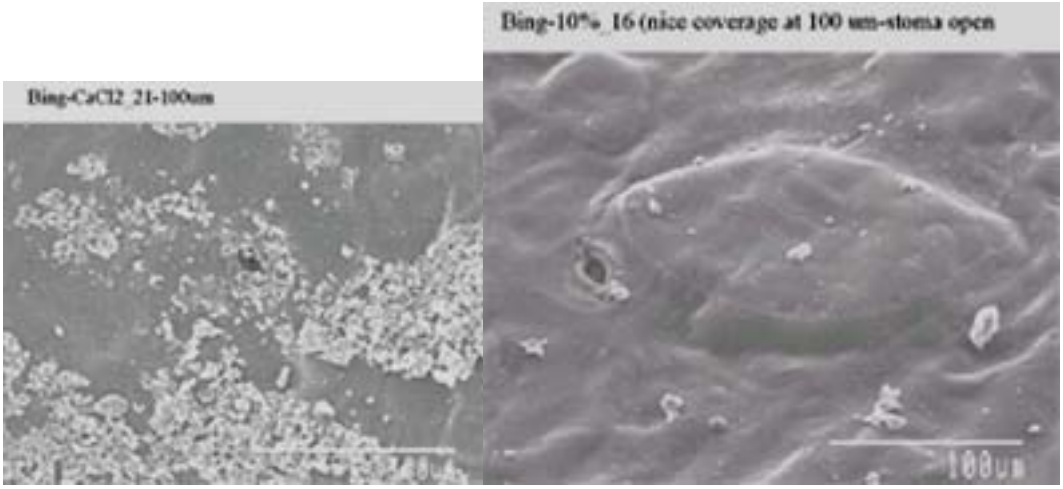

Fig. 6. Electron micrographs of the cuticle of ‘Bing’ cherries. The micrograph on the left was done on a cherry harvested from a tree sprayed with calcium chloride (1% w/v); the one on the right was from a cherry harvested from a tree sprayed with 10% (v/v) RainGard protectant (provided by Dr. Eric Curry).

Three electron micrographs (Figs. 5 and 6) compare the surface of cherries that were untreated, sprayed with calcium chloride, or sprayed with RainGard. Note the open stoma in each figure and the uniform coating on the cherry sprayed with RainGard.

Budget:

Project title: Suppressing cherry cracking and post harvest stem browning and water loss
PI: Larry Schrader (Co-PIs: M. Whiting and E. Curry)
Project duration: Two years (2003-2004)
Current year: Year 2 (2004)
Project total (2 years): $42,364

Year	Year 1 (2003)	Year 2 (2004)
Total	$19,956	$22,408

Current year breakdown

Item	Year 1 (2003)	Year 2 (2004)
Salaries	$10,000	$10,400 [1]
Benefits (34%)	3,400	3,536
Wages	1,600	1,700 [2]
Benefits (16%)	256	272
Equipment		
Supplies	3,800	3,500 [3]
Travel	900	1,000 [4]
Miscellaneous		2,000 [5]
Total	$19,956	$22,408

[1] Salary for an Associate in Research (25% time) for Schrader's program. The other 75% provided by WSU and other funds.
[2] Time-slip help for Whiting's program.
[3] Supplies included $800 for Dr. Curry to cover supplies needed for electron microscopy. Supplies included additional pumps used in "rain simulation" tests, sprinkler heads, etc., for overhead application of water, Mylar bags to enclose trees, chemicals, cell phone charges, other general supplies and possible payment for "crop destruct".
[4] Travel to experimental plots.
[5] Support for Dr. Gordon Brown in Tasmania, Australia to test efficacy of the cherry matrix in the Southern Hemisphere in 2003-04.