**FINAL REPORT** **YEAR**: 2013
**WTFRC Project Number: N/A**

**Project Title**: Prediction and mitigation of rain-induced cherry cracking

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Product suppliers: Garrett Bishop, Valent Biosciences (former Pace Intl.); Clive Kaiser, OSU; Adrian Roozen, Wilbur Ellis; Sean Musser, Cultiva IPM

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Other: Michael Young, formerly Stemilt; Glade Brosi; Suzanne Niemann; internal program staff: Manoella Mendoza, Tory Schmidt, Sandy Stone, Felipe Castillo, Udel Mendoza, Alfonso Ruiz and WTFRC seasonal crew

**Other funding sources**

All supplies and chemicals were donated by industry suppliers (value: $ 2,500-3,000/year).

**Budget history**

**Organization Name: WTFRC** **Contract Administrator: Kathy Schmidt**
**Telephone: 509 665 8271** **Email address: Kathy@treefruitresearch.com**

| Item | 2011 | 2012 | 2013 |
|---|---|---|---|
| **Salaries** | 7,000 | 4,366 | 12,256 |
| **Benefits** | 3,000 | 1,872 | 1,294 |
| **Wages** | 22,000 | 11,745 | 11,745 |
| **Benefits** | 11,000 | 5,033 | 5,033 |
| **Equipment** | 0 | 0 | 0 |
| **Supplies** | 192 | 200 | 150 |
| **Travel** | 116 | 150 | 0 |
| **RCA room rental** | 360 | 360 | 360 |
| **Revenue** | 12,500 | 14,000 | 8,000 |
| **Total** | **31,168** | **9,726** | **10,594** |

**Footnotes:** Salaries are estimated based on actual time spent on project for internal program staff: Schmidt, Castillo and Hanrahan. Wages reflect actual timeslip costs. Revenue is based on reimbursement from Cultiva IPM (2011, 2012) and Pace International/Valent Biosciences (2011-13)

**Note: Budget for informational purposes only. Research is funded through the WTFRC internal program.**

## RECAP ORIGINAL OBJECTIVES

Investigate rain cracking susceptibility and develop management strategies utilizing spray programs and prediction models.

1. Evaluate and optimize spray programs to reduce rain-induced cherry cracking.

2. Determine rain cracking susceptibility expression for common Northwest cherry cultivars during maturation and develop an easy test to determine cracking potential of individual blocks for grower use.

## SIGNIFICANT FINDINGS

Objective 1 (spray programs):

- Significant field cracking pressure (10% of fruit) is needed for conclusive product performance evaluation.
- When applied according to manufacturer recommendations, hydrophobic coatings can significantly reduce field cracking incidence (25-67%). Maximum protection is achieved when applied close to a rain event (48 hours or less), and a single coating can maintain coverage of up to 10 days, depending on rate of fruit growth (Table 1, Fig. 1).
- Hydrophobic coatings do protect fruit from cracking when rain of 0.5 inches is received within 24 hours (Fig. 1).
- Fruit quality and storage performance was largely unaffected by preharvest coating application (Table 1&2).
- A reduction of the number of applications of RainGard® from three to two did not affect cracking incidence (Table1, Fig.1).
- Tank mixing of RainGard® and gibberellic acid ($GA_3$) is a practical way to apply the first coating.
- SureSeal (sold as Parka™ since 2013) can cause fruit burning when applied early and/or to sensitive varieties. Some discoloration may be masked by final fruit color.
- VAPORGARD did not reduce rain induced cherry cracking in Tieton. It did leave a sticky residue that decreased fruit shine and caused phytotoxicity.

Objective 2 (cracking prediction):

- Cracking sensitivity development of cherries can be plotted utilizing a modified cracking index based on Christensen (1972).
- High variability exists (both level of cracking susceptibility and onset of sensitivity) within blocks of the same cultivar and within the same block in different years.
- Cracking susceptibility for commercially important varieties was determined (Table 4).
- Cracking susceptibility levels determined with a bench top test correlated well to actual cracking incidence observed in the field after rain events (Fig.1).
- Management decisions regarding use of protective coatings in blocks threatened by rain may be informed by use of the grower bench top test.
- A simplified grower version of the bench top test was developed (www.treefruitresearch.com).

**RESULTS & DISCUSSION**

Sweet cherry has the highest per acre value of any specialty crop in the Pacific Northwest, but every year some orchards experience crop loss due to rain-induced cracking. Cherry cracking is a complex phenomenon, with a dynamic interplay of tree physiology, fruit surface morphology, and genetic predisposition of fruit (Christensen, 1996). A reduction of cherry cracking can be achieved by a variety of means such as use of protective orchard covers, high velocity air drying, application of osmolytes during rain events, or prophylactic use of hydrophobic coatings (Christensen, 1996; Pennell and Webster, 1996; Schrader et al., 2005). Standard industry practice in the Pacific Northwest has been to reduce the duration of fruit wetness by application of osmotic solutions such as calcium nitrate or by blow-drying the trees with air-blast sprayers or helicopters. Multiple applications of antitranspirants such as VAPOR GARD are used by growers as well, although efficacy against rain-induced fruit cracking is not well established (Richardson, 1998; Schrader et al., 2005; Hanrahan unpublished).

The first commercially available hydrophobic fruit coating is distributed by Valent (formerly sold thru Pace International LLC, Wapato, WA). RainGard® is a mix of natural fatty acids that reduce the direct water absorption through the cuticle (Schrader and Sun, 2006). It forms a waxy, invisible film of the fruit surface and delays the time until fruit cracks and/or reduces the overall amount of cracking (Schrader et al., 2005; Schrader and Sun, 2006). Another fruit coating product developed by Clive Kaiser at Oregon State University has been commercialized in spring 2013. Known previously as SureSeal it is sold as Parka™ by (Cultiva IPM). SureSeal is an elastic, organic biofilm made of edible components (stearic acid, cellulose, calcium) (Kaiser, 2013).

<u>Objective 1: Evaluate and optimize spray programs to reduce rain-induced cherry cracking</u>

<u>*Effects of hydrophobic coatings on rain-induced cherry cracking*</u>

Between 2009 and 2013, the WTFRC internal program executed 31 field trials, but only 12 sites received sufficient rain to cause 10% or more field cracking in untreated fruit. This threshold mark needs to be reached in order to conduct meaningful product comparisons, because cherry cracking is highly variable. Both hydrophobic coatings (RainGard® and SureSeal) performed well in reducing the incidence of cracking in cherries. In WTFRC trials from 2009-12, RainGard® consistently reduced field cracking by by 25- 57% in trials with significant cracking pressure (Fig. 1; Table 1) and SureSeal reduced cracking by 44-67%. Both coatings remained effective for 5-7 days (max. observed 10 days) and up to 0.56 inches of rain (Figure 1). Single rain events of more than 0.5 inches, like those observed in 2013, did overwhelm the capacity of both products to prevent cracking of fruit (data not shown). SureSeal reduced fruit cracking significantly and consistently in all experiments conducted by WTFRC (examples shown in Table 1), but has proven to be difficult to use under real orchard scenarios: a high volume of water (at least 200 gal/acre) is needed to achieve good performance regardless of planting system, and phytotoxicity may be an issue with some varieties when applied to light green fruit and/or higher than recommended product concentration.

<u>*Effects of variable application frequency of RainGard® and tank mixing with $GA_3$ on rain-induced cracking*</u>

One barrier for wider adoption of RainGard® has been the need for 3 separate weekly applications to maintain optimum product performance. Hence, in 2012 we tested two application scenarios: a) three weekly applications of RainGard® and b) two applications of RainGard®: first as a tank mix with $GA_3$, then followed by a second application of RainGard® alone once fruit had reached a cracking index reading of 20 and before a rain event (Figure 1). Both treatment scenarios resulted in significantly reduced fruit cracking in RainGard® treated areas of the trial orchard (Table 1).

*Fruit quality and postharvest performance*

Fruit quality was assessed in all five years of the study to ensure that none of the treatments negatively affected fruit quality. Commercially important quality parameters showed year to year variation (Table 1, Table 2). For example, mean fruit size in untreated control fruit ranged from 11.1g in 2012 to 14.5g in 2010. Fruit color had the least amount of yearly variability, while soluble solids content fluctuated considerably (Table 1).

- RainGard® : At harvest, fruit quality of RainGard® treated fruit remained unaffected (example for Tieton in Table 1). The lone exception was the increased mean titratable acidity level for RainGard® in 2011 (Table1). Maturity of fruit stored for two weeks in cold storage was not influenced by in-season RainGard® applications (data not shown). The amount of stem browning, fruit pitting and fruit weight loss in storage was equal between treated and untreated fruit (Table 2), except for 2011 and 2012 (handgun), when RainGard® treated fruit had greener stems after storage.
- SureSeal: At harvest, fruit quality of SureSeal treated fruit remained unaffected (example for Tieton Table 1). Maturity of fruit stored for two weeks in cold storage was not influenced by in-season SureSeal applications (data not shown). The amount of stem browning, fruit pitting and fruit weight loss in storage was equal between treated and untreated fruit (Table 2), except for 2012 (handgun), when SureSeal treated fruit had greener stems after storage.
- VAPORGARD: At harvest, fruit quality of VAPORGARD treated fruit remained unaffected (example for Tieton Table 1). Maturity of fruit stored for two weeks in cold storage was not influenced by in-season VAPORGARD applications (data not shown). The amount of stem browning, and fruit pitting in storage was equal between treated and untreated fruit (Table 2).

Both, Parka and VAPORGARD can cause burning of young fruitlets as reported in 2012 (see cont. report).

Table 1. Effects of preharvest RainGard™ , SureSeal , and VAPORGARD applications on harvest quality parameters of cherries. 'Tieton'/GiSelA6. Pasco, WA. WTFRC 2009-2012.

| **Treatment** | **Weight** | **Acids** | **Sugars** | **Firmness** | **Diameter** | **Row Size** | **Color** | **Cracking**[Z] |
|---|---|---|---|---|---|---|---|---|
| | (g) | (% malic acid) | (% Brix) | (g/mm) | (mm) | | (1-7) | (%) |
| ***2009 (grower applied)*** | | | | | | | | |
| RainGard® | 12.2 ns | 0.691 ns | 14.7 ns | 277 ns | 30.5 ns | 9.1 ns | 4.3 ns | 15 a |
| UTC | 12.8 | 0.757 | 15.7 | 278 | 30.9 | 8.9 | 4.4 | 31 b |
| ***2010 (grower applied*** | | | | | | | | |
| RainGard® | 14.5 ns | 0.52 ns | 18.9 ns | 227 ns | 31.7 ns | 8.7 ns | 5.3 ns | 38 a |
| Control | 14.5 | 0.49 | 18.8 | 238 | 32.1 | 8.6 | 5.4 | 51 b |
| ***2011(grower applied)*** | | | | | | | | |
| RainGard® | 13.7 ns | 0.78 a | 22.0 ns | 348 ns | 30.8 ns | 8.9 ns | 4.4 ns | 10 b |
| SureSeal [Y] | 12.4 | 0.77 ab | 20.6 | 352 | 30.7 | 9.0 | 4.6 | 9 b |
| Control | 13.4 | 0.68 b | 20.9 | 322 | 30.5 | 9.0 | 5.4 | 16 a |
| ***2012 (handgun)*** | | | | | | | | |
| RainGard® | 11.1 ns | 0.57 ab | 14.7 ab | 256 ns | 26.8 ns | 10.2 ns | 5.1 ab | 11 b |
| SureSeal | 10.2 | 0.60 a | 15.5 a | 261 | 26.7 | 10.3 | 5.2 ab | 9 b |
| VAPORGARD | 11.9 | 0.55 b | 14.5 b | 238 | 27.0 | 10.2 | 4.9 b | 31 a |
| Control | 11.1 | 0.57 ab | 14.7 ab | 256 | 26.8 | 10.3 | 5.7 a | 27 ab |
| ***2012 (grower applied)***[X] | | | | | | | | |
| RainGard®/$GA_3$ | 12.2 ns | 0.59 ns | 17.2 ns | 262 ns | 27.3 ns | 10.1 ns | 4.0 ns | 15 b |
| RainGard® | 11.9 | 0.62 | 17.3 | 259 | 26.8 | 10.2 | 4.0 | 12 b |
| Control | 12.7 | 0.62 | 17.6 | 250 | 27.5 | 10.0 | 4.3 | 28 a |

[Z]on tree reading based on 400 frt./rep; [Y] SureSeal is sold commercially as Parka since 2013; [X] RainGard™ ™ /$GA_3$ = 1st application as tank mix with $GA_3$' 2nd application when cracking index exceeded 20 and significant rain in the forecast; RainGard™ ™ = followed weekly application schedule starting at light green.

Table 2. Effects of preharvest RainGard™ , SureSeal , and VAPORGARD applications on stem browning, fruit pitting and weight loss after 14 days of cold storage at 1°C on cherries. 'Tieton'/GiSelA6. Pasco, WA. WTFRC 2009-2012.

| | Stem browning | | | | Pitting | | | Weight loss |
|---|---|---|---|---|---|---|---|---|
| | 0-25 % | 26-50 % | 51-75 % | 76-100 % | Clean % | Slight % | Severe % | % |
| | | | | | ***2009(grower applied)*** | | | |
| RainGard® | 71 ns[Z] | 17 ns | 11 ns | 1 ns | 96 ns | 4 ns | 0 ns | 2 ns |
| Control | 63 | 21 | 12 | 5 | 92 | 7 | 1 | 3 |
| | | | | | ***2010(grower applied)*** | | | |
| RainGard® | 55 ns | 27 ns | 13 ns | 5 ns | 77 ns | 23 ns | 0 ns | 2 ns |
| Control | 51 | 26 | 13 | 10 | 51 | 32 | 18 | 2 |
| | | | | | ***2011(grower applied)*** | | | |
| RainGard® | 41 ns | 14 b | 22 ns | 24 ns | 90 ns | 8 ns | 2 ns | 6 ns |
| SureSeal | 37 | 17 ab | 22 | 25 | 93 | 6 | 1 | 7 |
| Control | 25 | 23 a | 18 | 25 | 92 | 6 | 2 | 3 |
| | | | | | ***2012(grower applied)*** | | | |
| RainGard® | 79 ns | 14 ns | 5 ns | 2 ns | 91 ns | 7 ns | 2 ns | - |
| RainGard™/$GA_3$ | 81 | 10 | 7 | 3 | 96 | 4 | 0 | - |
| Control | 83 | 9 | 5 | 2 | 93 | 6 | 2 | - |
| | | | | | ***2012 (handgun)*** | | | |
| RainGard® | 84 ns | 12 ns | 3 b | 1 b | 89 ns | 9 ns | 1 ns | - |
| SureSeal | 82 | 14 | 3 b | 1 b | 95 | 5 | 1 | - |
| VAPORGARD | 77 | 15 | 8 ab | 1 b | 87 | 11 | 2 | - |
| Control | 72 | 14 | 9 a | 4 a | 92 | 8 | 0 | - |

Objective 2: Track and model rain cracking susceptibility development during maturation

We observed blocks of commercially important cultivars during the month before harvest from 2009-2013. Initial fruit weight averaged 3-4g and color was green to light green. Samples for the artificial cracking test were taken bi-weekly.

Bing cherries in both locations tested in bench-top assays in 2013 were already cracking sensitive at the start of the test series 24 and 25 days pre-harvest. Cracking index (CI) levels in excess of 20 were recorded for 21 or 7 days respectively (Table 3). Based on results from 5 consecutive years, Bing cherries vary considerably, both in the on-set of cracking sensitivity (33-14 days before harvest) and the duration of the phase of high sensitivity (0-21 days).

Of the two Tieton blocks observed in 2013, both were cracking susceptible over a long period of time (22 or 25 days). However, while the block in Zillah sustained CI levels above 20 for 9 days, the block in Sawyer recorded only 4 consecutive days, with one additional day 22 days before harvest. Although Tieton cherries are typically considered prone to rain induced cracking, our data from 5 years suggests variability between years and by block.

Sweetheart, Santina, and Skeena all had prolonged periods of cracking susceptibility, with 13-28 days of potential for cracking (Table 5). Benton was highly cracking sensitive only shortly before harvest in 2013 and 2012.This data corresponds well with industry's experience with these varieties. However, some varieties have not been consistent within years. For example, Sweetheart had a moderate cracking potential in 2012.

Overall, variability in cracking susceptibility as observed especially in Bing, Tieton, Santina, and Sweetheart, highlights the need to supplement general variety knowledge with year-to-year and block-by-block information regarding cracking potential. The bench top test has shown sensitive enough to pick up these swings and we recommend using it in blocks threatened by rain to determine the economic benefits/thresholds of applying protective coatings. For example, in 2012 a Tieton orchard in Pasco sustained 1.02 inches of total precipitation between May 23 and June 7, with three events at or above 0.1 inches, the general threshold for rain induced cracking (Figure 1). The fruit was susceptible during each of the main rain events, and sustained cumulative cracking. In both trials set-up in the Pasco Tieton block, applications of cracking protectants were made ahead (1 or 8 days) of the anticipated rainfall, and significant reductions in damage was observed (Table 1, Fig. 1).

To summarize our experience with locally grown cherry varieties, we have developed a table to show general varietal sensitivity (Table 4). We have added the colum 'variable' to highlight the seasonal swings of some varieties grown in the Pacific Northwest.

Table 3: Days of susceptibility (DOS; CI > 0), days of high susceptibility (DOHS; CI ≥ 20) and maximum cracking index (max CI) for cherry orchards in Washington. WTFRC 2013.

| **Variety** | **Location** | **DOS** | **DOHS** | **Max CI** |
|---|---|---|---|---|
| Tieton | Zillah | 22 | 9 | 22 |
| | Sawyer | 25 | 4* | 65 |
| Santina | Outlook 2 | 24 | 20 | 77 |
| | Zillah | 28 | 24 | 29 |
| | Outlook 3 | 28 | 28 | 55 |
| Benton | Zillah | 15 | 5 | 70 |
| | Outlook 2 | 21 | 7 | 59 |
| Bing | Zillah | 24 | 7 | 83 |
| | Outlook 2 | 25 | 21 | 60 |
| Skeena | Outlook 1 | 13 | 13 | 83 |
| Sweetheart | Outlook 1 | 15 | 15 | 88 |

*1 DOHS @ 22 days before harvest

Table 4: Overall cracking sensitivity of cultivars grown in the Pacific Northwest

| **High** | **Variable*** | **Medium** | **Low** |
|---|---|---|---|
| Early Robin | Sweetheart | Rainier | Regina |
| Van | Santina | | Lapins |
| Skeena | Tieton | | |
| Benton | Bing | | |

*Variable = can switch between medium to high sensitivity.

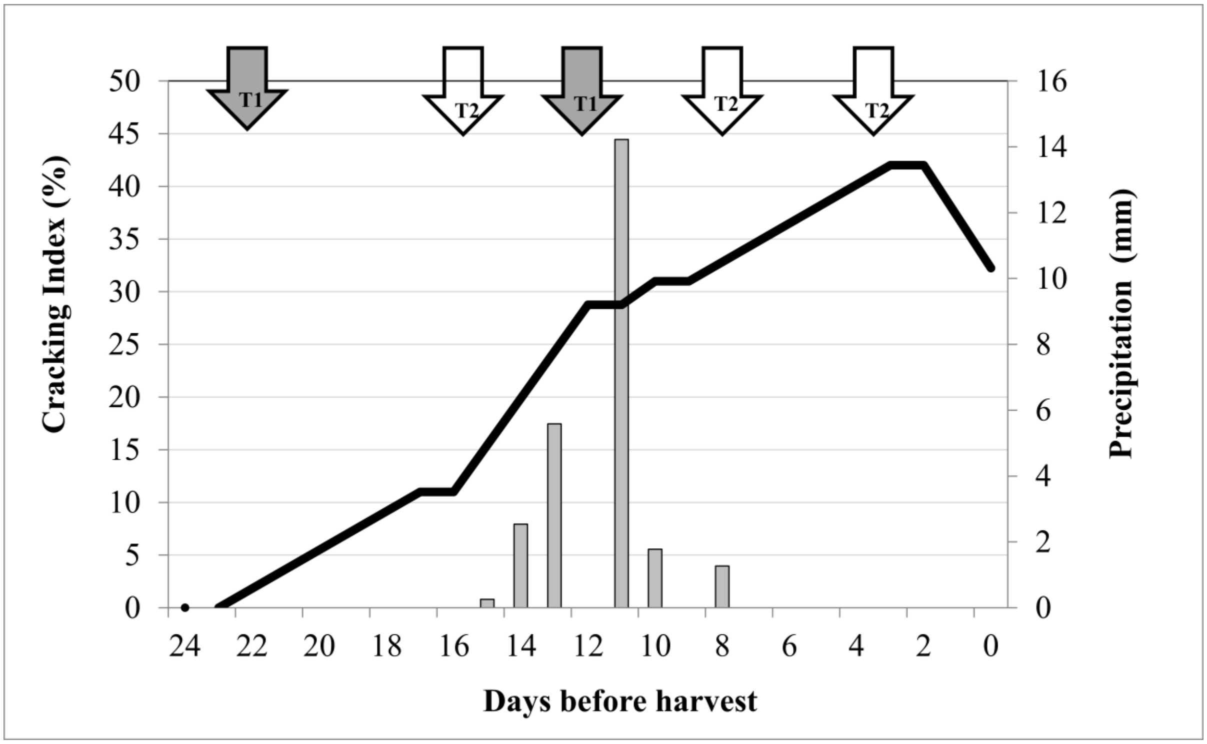


Fig.1. Development of cracking index (%), daily precipitation (mm) and sequence of treatments for 'Tieton'/GiSelA6. Pasco, WA. WTFRC 2012.

T1: First application = RainGard®+ $GA_3$; Second application: RainGard®
T2: Three times RainGard® application

**LITERATURE CITED**

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**EXECUTIVE SUMMARY**

Rain exclusion by means of prophylactic spray application of hydrophobic coating materials has been of interest to growers in the Pacific Northwest for the past decade (Schrader and Sun, 2006). Hence, applied horticultural field trials to test overall performance of RainGard®, the only commercially available product until 2013, were initiated by the WTFRC in 2007. In 2013 another hydrophobic coating, SureSeal (trade name: Parka™), was commercialized. Comparitive performance data between antitranspirants (VAPORGARD) and hydrophobic coatings (SureSeal, RainGard®) has been generated between 2012 and 2013.

Although we have conducted 31 trials in commercial orchards since 2007 (more than 50 overall), only a limited amount of information has been generated due to lack of adequate rain events. In the experiments described in this report, RainGard® and SureSeal reduced cracking incidence of fruit significantly and consistently, even under strong rain pressure (up to 0.56 inches).

However, RainGard® application schedules of three weekly applications, as suggested by the manufacturer, pose a significant cost to growers and reduce availability of equipment and personnel needed for other activities such as harvest. Hence, optimization of spray programs by 1) tank mixing product with $GA_3$, and/or 2) reduction of the number of total applications, can further increase the attractiveness of RainGard® and similar products. Our trials have demonstrated that a reduction of the number of applications from three to two did not reduce effectiveness of the product. If timed correctly, less applications may be sufficient to effectively coat the fruit. To achieve this, knowledge of actual cracking sensitivity of blocks prior to threatened rain events is needed and can be easily achieved with a simple grower version of the bench top test developed during the course of this study.