Project title: Control of Sunburn in Apples with RAYNOX

PI: Larry Schrader, Horticulturist

Organization: WSU Tree Fruit Research and Extension Center, Wenatchee
(509) 663-8181 ext. 265; schrader@wsu.edu

Cooperators: Jim McFerson, Tom Auvil, and Tory Schmidt, WTFRC, Wenatchee
Leo Jedlow and Jianshe Sun, WSU TFREC, Wenatchee

Objectives:
1. Establish the optimal timing, rates and application frequency of RAYNOX to apples for protection from sunburn.
2. Study efficacy of RAYNOX as a stabilizer or carrier for nutrients, growth regulators and other compounds sprayed on trees or fruit.

Significant findings:
1. RAYNOX effectively protects apples from sunburn damage. In four years of field testing in several growers’ orchards, RAYNOX and Surround were similar in efficacy for sunburn protection. Both protectants reduced sunburn about 50% on average.
2. RAYNOX is a liquid concentrate and is easily diluted with water in the sprayer tank.
3. RAYNOX does not interfere with color development. Fruit previously sunburned recovers better (i.e., color over) when treated with RAYNOX.
4. RAYNOX leaves no unattractive residue on fruit, in the calyx or in the stem bowl.
5. RAYNOX blocks substantial UV-B radiation, a cause of sunburn browning in apples.
6. RAYNOX also reflects ultraviolet and infrared radiation that is normally converted to heat when absorbed by apples.

Methods:
Sunburn trials were conducted in growers’ orchards during 2000, 2001 and 2002. Treatments were applied with the Proptec low volume sprayer. In 2000, RAYNOX was diluted 1:1 and applied at 50 gal/acre (gpa). In 2001, RAYNOX was diluted so that application rates were 10 or 20 gpa of RAYNOX concentrate. No significant differences were observed between the two rates during 2001. Thus, only 10 gallons of RAYNOX concentrate were diluted and applied during 2002. The incidence of sunburn was evaluated at different stages of maturity. At harvest, fruit quality and size were assessed to see if RAYNOX or Surround affected these traits.

In a new experiment this year, various formulations (i.e., Surround, RAYNOX, Vapor Gard, and with water as a control) were applied to ‘Fuji’ apples starting in early July 2002 to protect apples from sunburn. The incidence of sunburn was very high in these plots. We devised a new system for classifying the extent of sunburn damage. This more extensive evaluation system allowed us to determine whether sunburned fruit recovered, became more sunburned, or remained the same after September 9. Six evaluation classes were established as follows: Class 0: no sunburn; Class I: a light yellow spot on the sun-exposed side; Class II: a more intense yellow spot; Class III: a yellow spot with apparent lenticel breakdown; Class IV: a dark tan spot; and Class V: a necrotic spot. Ten apples in each of five classes (Class 0 through Class IV) were tagged on September 9 in each of the four treatments. With four replications, 40 apples of each class and variety were tagged. These 800 fruits
were harvested (October 22) and evaluated again to determine whether sunburn damage increased (i.e., sunburn damage moved the fruit into a higher class), whether sunburn damage was less apparent due to coloring over, or whether fruits remained in the same class. Then all fruits were placed in cold storage at Stemilt. The fruits will be evaluated periodically to see if pigment changes during storage cause sunburn to become more visible in fruit of each class and whether development of stain differs in the various classes.

Results and discussion:

Sunburn trial with ‘Gala’ in 2000:
RAYNOX was diluted 1:1 and applied at 50 gal/A (gpa) on June 27, July 10, July 24 and August 7 (4X) or on June 27 and July 24 (2X) with a Proptec tower sprayer. On August 9, McFerson’s team found no significant differences in sunburn between RAYNOX 2X (5.28% sunburn) or RAYNOX 4X (4.00% sunburn) and the control (5.62% sunburn).

Fig. 1. Evaluation of sunburn for Gala apples treated with various formulations

On August 16, Schrader’s team found that RAYNOX 2X (8.84% sunburn) and RAYNOX 4X (6.24% sunburn) were significantly lower than the control (12.86% sunburn) (Fig.1). The higher incidence of sunburn observed on August 16 was expected, as some of the highest fruit temperatures for the summer were recorded during the first half of August in Wenatchee. In Wenatchee, fruit skin temperature exceeded 113°F on 9 days in early August 2000. It seems likely that fruit temperature at this orchard also exceeded 113°F at least once during that interval and caused sunburn on fully exposed fruit.

Sunburn trial with ‘Fuji’ in 2000:
RAYNOX was diluted 1:1 and applied at 50 gpa on June 27, July 10, July 24 and August 7 (4X) or on June 27 and July 24 (2X) with a Proptec sprayer. On August 9, McFerson’s team reported no significant differences between RAYNOX 2X (2.87% sunburn) or RAYNOX 4X (3.15% sunburn) and the control (5.27% sunburn). On September 22, McFerson’s team found RAYNOX 4X (3.25% sunburn) to be better than the control (8.05% sunburn) but not different from RAYNOX 2X (4.17% sunburn). On August 28, Schrader’s team found RAYNOX 4X (4.92% sunburn) and RAYNOX 2X (5.84% sunburn) to be significantly better than the control (10.59% sunburn) (Fig. 2). On September 28, RAYNOX 4X (4.53% sunburn) and RAYNOX 2X (3.70% sunburn) were not significantly different than the control (6.72% sunburn).
In an experiment in Wenatchee, we found that a sunburn event occurred on August 24. Fruit skin temperature (121°F) was the highest for the season that day in Wenatchee. This may explain the large increase in sunburn observed at this site on August 28 as compared to the August 9 evaluations. There was only one time later in the season (i.e., September 14) when the fruit skin temperature reached 113°F at the Wenatchee site, and it is unlikely that this caused sunburn in these ‘Fuji.’ The observation that sunburn incidence was lower on September 28 than on August 28 is probably due to red pigment synthesis in September that masked some of the sunburn browning.

**Sunburn trial with ‘Cameo’ in 2001:**
In a long-row trial conducted with ‘Cameo,’ sunburn was reduced ~50% by RAYNOX at 10 gpa and by RAYNOX at 20 gpa (three applications made with Proptec sprayer) (Fig. 3). The incidence of sunburn was fairly high on apples in the upper part of the canopy. The evaluator stood on a ladder and evaluated 100 apples above the fourth wire of the trellis support system. There was little sunburn in the lower part of the canopy, as apples were less exposed to the sun and trees in an adjacent row shaded many fruits. Sunburn in apples treated with RAYNOX at 10 and 20 gpa was significantly lower than in the controls or Surround-treated fruit. Apples sprayed with Microna Shade suspended in a waxy matrix or sprayed with the matrix alone were intermediate and not significantly different than either other group (Fig. 3). Sunburn recorded by McFerson’s team was lower because the evaluator stood on the ground and could not see the higher incidence of sunburn on fruit near the top of the canopy.
Fig. 3. Evaluation of sunburn on ‘Cameo’ apples treated with various formulations. Treatments were applied with the Proptec low volume sprayer at 50 gpa. Bars with the same letter are not significantly different (P<0.05) from each other, according to the Duncan’s Multiple Range Test.

**Sunburn trial with ‘Gala’ and ‘Fuji’ in 2002:**
During 2002, experiments were conducted on ‘Gala,’ ‘Fuji,’ and ‘Granny Smith.’ All treatments were applied on four dates: July 5, July 8, July 22, and August 7. RAYNOX (10 gpa) was diluted and applied with the Proptec tower sprayer at a rate of 50 gpa. Surround was applied at a rate of 50 lb./acre on July 5 and at a rate of 25 lb./acre at later applications. Vapor Gard was applied at a rate of 1 gal/acre each time. Sunburn was evaluated periodically, and representative data are shown for ‘Gala’ and ‘Fuji.’

With ‘Gala’ evaluated for sunburn on September 4, Surround suppressed sunburn more than other treatments but was not significantly different statistically from RAYNOX (Fig. 4). With ‘Fuji’ evaluated for sunburn on August 21, incidence of sunburn was lowest in the RAYNOX-treated fruit, but RAYNOX and Surround suppressed sunburn to nearly the same extent (Fig. 5). By September 19, sunburn in ‘Fuji’ was substantially higher for all treatments due to “sunburn events” on September 11, 12, and 13. Surround-treated apples had the lowest incidence of sunburn, but were not different statistically from apples treated with RAYNOX. Fruit treated with Vapor Gard showed the highest incidence of sunburn (Fig. 6).
Fig. 4. Percent sunburn observed in ‘Gala’ on September 4, 2002, after four applications of three sunburn protectants or water (control). Bars with the same letter are not significantly different (P<0.05) from each other, according to the Duncan’s Multiple Range Test.

Fig. 5. Percent sunburn observed in ‘Fuji’ on August 21, 2002, after four applications of three sunburn protectants or water (control). Bars with the same letter are not significantly different (P<0.05) from each other, according to the Duncan’s Multiple Range Test.
Study on Late-Season Changes in Sunburn Injury in ‘Fuji’, 2002:
Some controversy exists about the extent to which sunburn injury is masked by late-season pigment changes. That is, can a fruit that has mild sunburn injury accumulate anthocyanins or other pigments and mask that sunburn injury by harvest time? We designed an experiment to track the changes that occurred in ‘Fuji’ fruit beginning September 9, 2002, and ending at harvest on October 22. All 800 fruits were re-evaluated for sunburn on October 22, and any changes from the previous evaluation on September 9 were noted. Some fruit showed some recovery from the earlier sunburn damage (Fig. 7). This was especially true for fruit treated with RAYNOX. About 14% of the fruit showed less sunburn injury than on September 9. Some fruits were sunburned again during the period between September 11 to 13 and moved to a class with a higher number indicating more serious sunburn (Fig. 8). This was especially true for control and Vapor Gard-treated fruit. Some fruits were sunburned so badly that they advanced to sunburn necrosis (Class V) on October 22 (Fig. 9). RAYNOX-treated apples showed the least necrosis on October 22.

Fig. 6. Percent sunburn observed in ‘Fuji’ on August 21, 2002, after four applications of three sunburn protectants or water (control). Bars with the same letter are not significantly different (P<0.05) from each other, according to the Duncan’s Multiple Range Test.
Fig. 7. Percentage of ‘Fuji’ apples on which some recovery from sunburn browning was observed between September 9 and October 22, 2002.

Fig. 8. Percentage of ‘Fuji’ apples that developed more severe sunburn between September 9 and October 22, 2002. Conditions were favorable for a “sunburn event” on September 11 to September 13.
Fig. 9. Percentage of ‘Fuji’ apples that advanced from sunburn browning to sunburn necrosis between September 9 and October 22, 2002.

**Modes-of-action of RAYNOX:**
Quartz crucibles (100 ml size) were coated with RAYNOX. After drying, the amount of light of various wavelengths that passed through (i.e., transmission) the RAYNOX and crucible were measured near high noon on a clear day. Five sensors calibrated to detect different parts of the solar spectrum were used.

UV-B transmission was decreased more than other types of light. For examples, UV-B transmission through the crucible was inhibited nearly 80% by 50% RAYNOX. We suggest that RAYNOX protects fruit from sunburn by blocking transmission of a substantial amount of the damaging UV-B to the fruit’s surface.

Other studies with a reflectometer have shown that RAYNOX reflects some of the UV-B. RAYNOX also reflects some of the infrared radiation.
Budget:

Project title: Control of Sunburn in Apples with RAYNOX
PI: Larry Schrader, Horticulturist
Project duration: 2001-2002
Project total (2 years): $11,840

<table>
<thead>
<tr>
<th>Year</th>
<th>Year 1 (2001)</th>
<th>Year 2 (2002)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>5,900</td>
<td>5,940</td>
</tr>
</tbody>
</table>

Current year breakdown

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Benefits (%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wages¹</td>
<td>4,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Benefits (16%)²</td>
<td>600</td>
<td>640</td>
</tr>
<tr>
<td>Equipment</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Supplies</td>
<td>700</td>
<td>700</td>
</tr>
<tr>
<td>Travel</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>5,900</td>
<td>5,940</td>
</tr>
</tbody>
</table>

¹ Time-slip will help apply treatments, evaluate trials, harvest and analyze data.
² Employee benefits are 16% of salaries for time-slip wages.

Summary of total cost of project: $11,840