FINAL REPORT ADDENDUM NO. 1
WTFRC PROJECT # TR-02-235

Project Title: Reduction of Pesticide Inputs, Worker Exposure, and Drift Through Alternative Sprayer Technology

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Objectives:

The goal of our research has been to help growers reduce the cost of pesticide applications while simultaneously maintaining efficacy, reducing worker exposure, and off-target drift. This project was designed to help meet the goals of the 'technology roadmap' to reduce production costs while enhancing fruit quality and sustaining a quality environment. The following objectives were studied during a three-year project that involved a combination of field and laboratory experiments.

1. Determine residue deposition from a reduced volume alternative sprayer (i.e., the Proptec tower) using reduced rates of active ingredient application.
2. Determine efficacy of reduced application rate residues deposited by a reduced volume sprayer and the conventional airblast sprayers.
3. Determine the residue decline rate of reduced application rates using chemical and biological assays.
4. Improve the accuracy of estimating worker exposure by determining the rate in decline of dislodgeable foliar residues after application of reduced active ingredient rates.
5. Determine the drift reduction potential of alternative sprayers.

At the time the final report was submitted, residue analysis of field-collected apples was in progress. A new method called QuEChERS, recently developed by the USDA, was adapted to reduce solvent use, improve lab safety, and speed analysis of the hundreds of apple samples required to develop valid data for field experiments. The QuEChERS method had to be validated for both Guthion and Assail residues, and method detection limits had to be determined. This process necessarily reduced the ability to produce the data in time for the final report. This ADDENDUM represents an analysis of Guthion residues and bioactivity with respect to objectives 1, 2, and 3. A similar analysis of residues is still in progress for Assail residues.

Significant Findings:

1. The weight and surface area of apples were measured on each day of collection. The surface area to weight ratio was above 2 for apples collected in late May and early June, but later in June and during July the ratio was closer to 1. Apples collected during August had a ratio less than 1 (See **Figure 1**). These measurements were made so that data could be expressed on a surface area basis as well as a weight basis.
2. Initially deposited Guthion residues on a weight basis (i.e., micrograms Guthion per gram apple, µg/g) and rate of decline (as determined by the slope in trend of residues recovered over time) were similar for the first and second cover spray (see **Figures 2 and 3**).
3. Residues were transformed from a weight basis to a surface area basis (i.e., micrograms Guthion per square centimeter of apple surface, µg/cm^2) to estimate bioavailability of residues. Transformation of Guthion residues from a weight basis to a surface area basis changed the perspective of bioavailable residues during the May and June collections (first cover spray) as discussed in findings 4 and 5 below (see **Figures 2 and 3**).
4. The residues (as µg/cm^2) on smaller apples collected after the first cover spray were significantly lower than residues on apples collected after the second cover spray (See **Figures 2 and 3**). These

data suggest that codling moth neonates may be exposed to less residues as they crawl across smaller apples than larger apples.

5. Residues (expressed both on an apple weight and surface area basis) resulting from the airblast sprayer treatment were significantly higher on apples collected from the mid canopy than from the top canopy level for both the first and second Guthion cover spray (see **Figure 2**).
6. Residues (expressed both on an apple weight and surface area basis) resulting from the Proptec sprayer treatment were not significantly different between the mid and top canopy collections after the first cover spray. However, after the second cover spray, residues on apples from the mid canopy level were significantly higher than on apples from the top canopy level (see **Figure 3**).
7. Residues (as $\mu g/cm^2$) on apples from the mid and top canopy level were not significantly different between airblast and Proptec sprayer treatments following the first and second cover spray (see **Figure 4**). However, residues on apples from the top canopy level were numerically higher in the Proptec treatment than in the airblast treatment.
8. Bioassays were conducted to determine the percentage reduction in neonate CM injury (the sum of stings and entry holes) on field sprayed apples compared to untreated apples. No significant differences were observed between apples collected 7, 14, 21, or 28 days after the first cover spray (see **Figure 5**). Similarly, no significant differences were observed in Guthion residues collected during the same time period. However, average percentage reduction in injury did numerically decline over the first month after application coincidentally with a decline in Guthion residues.
9. Bioassays of neonate CM on apples collected during the first two weeks after the second cover spray showed no statistically significant differences in percentage reduction of entry holes for any treatment comparison (i.e., mid vs. top canopy; airblast vs. Proptec sprayer) (See **Figure 6**). During this time period, Guthion residues numerically declined, but the loss was only statistically significant for apples collected from the airblast sprayer treatment at mid canopy level.
10. Residues (as $\mu g/cm^2$) on apples from the first cover spray (both airblast and Proptec treatments) were significantly lower than residues on leaves (leaf data shown in submitted final report). Apple residues after the second cover spray were more comparable to the magnitude of residues on leaf surface. However, percentage reductions in larval injury on apples (as measured by numbers of entry holes) were much lower than expected based on the 100% mortality observed when larvae were exposed to residues on leaves. This observation suggests that residues on apples may be less bioavailable for uptake by crawling neonate CM than comparable quantities of residues on leaves.
11. Residues on apples collected August 29, 2004 (a date approximating the commercial harvest date for Gala apples in the lower Yakima Valley) coincided with a pre-harvest interval (PHI) of 94 days after the first cover spray or 37 days after the second cover spray. Residues for both pre-harvest intervals were below the Guthion tolerance of 1.5 µg/g. Harvest residues were not significantly different between sprayer treatments (see **Table 1**). Harvest residues were significantly lower on apples taken from the top of the canopy compared to apples collected from the mid canopy level.

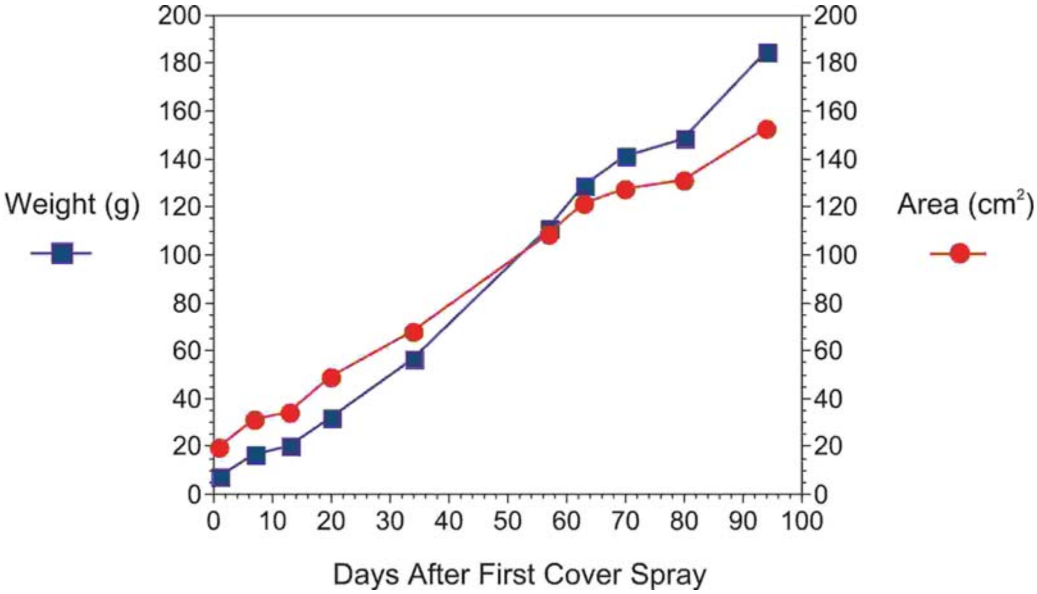

Figure 1. Relationship between apple weight and surface area during crop year 2004. The age of the apple was expressed relative to the days after the first cover spray. Surface area was determined from measurement of two perpendicular diameters and application of the area formula for a sphere ($A = 4 * pi * r^2 = pi * D^2$).

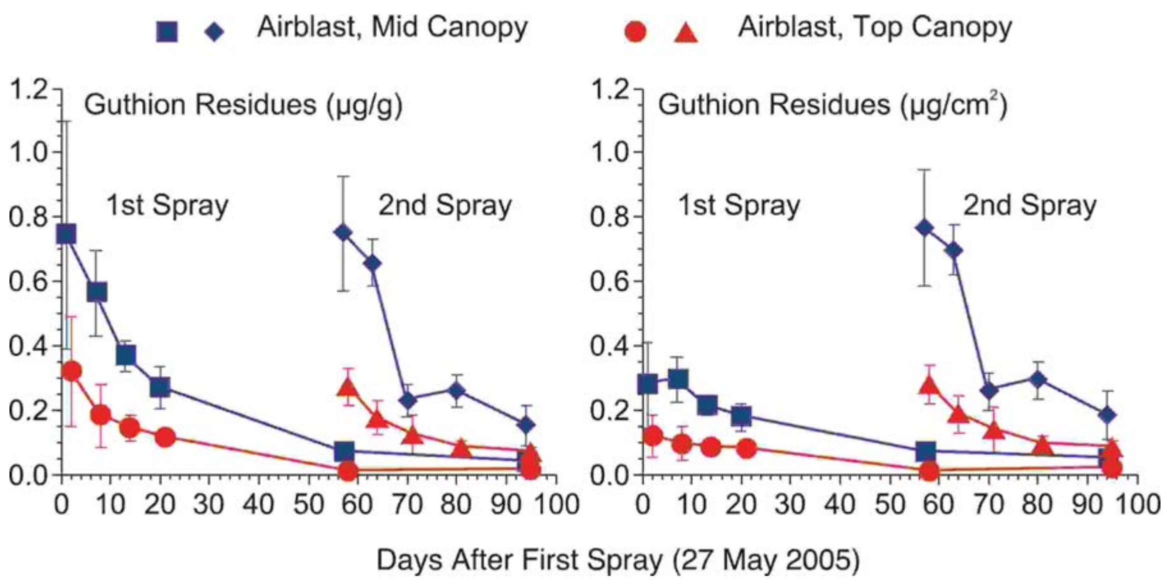

Figure 2. Deposition and decline of Guthion residues (expressed as µg/g or as µg/cm^2) on apples after two cover sprays during 2004 at the H&M Orchard. Applications were made by a Pakblast (airblast axial fan) sprayer, and apples were collected from the mid canopy and top canopy levels. Symbols represent the mean residue recovered (n=6), and the error bars represent the 95% confidence interval for the mean. Overlapping error bars indicate that residues recovered from different treatments (i.e., canopy level and day of collection) are not significantly different (p = 0.05).

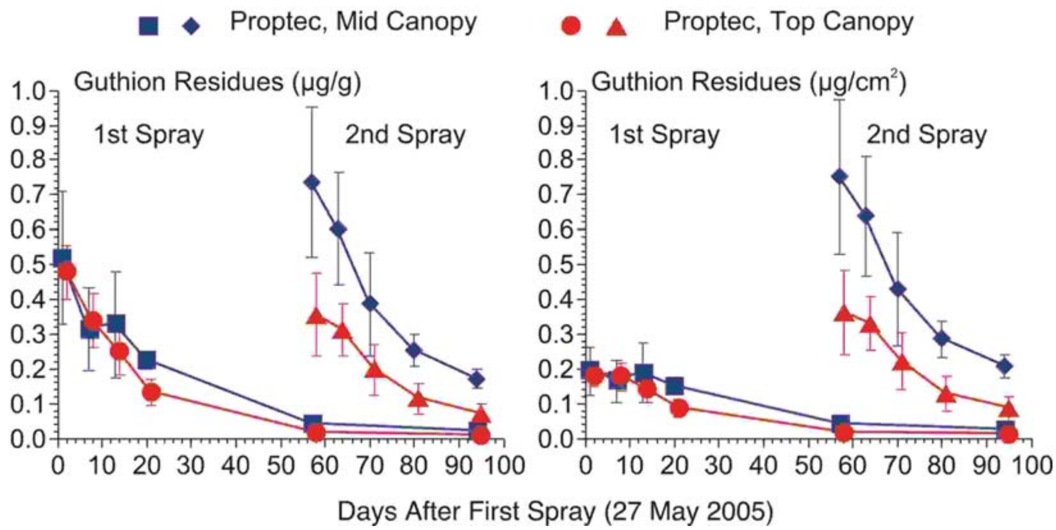

Figure 3. Deposition and decline of Guthion residues on apples (expressed as µg/g or as µg/cm^2) after two cover sprays during 2004 at the H&M Orchard. Applications were made by a Proptec single tower sprayer, and apples were collected from the mid canopy and top canopy levels. Symbols represent the mean residue recovered (n=6), and the error bars represent the 95% confidence interval for the mean. Overlapping error bars indicate that residues recovered from different treatments (i.e., canopy level and day of collection) are not significantly different (p = 0.05).

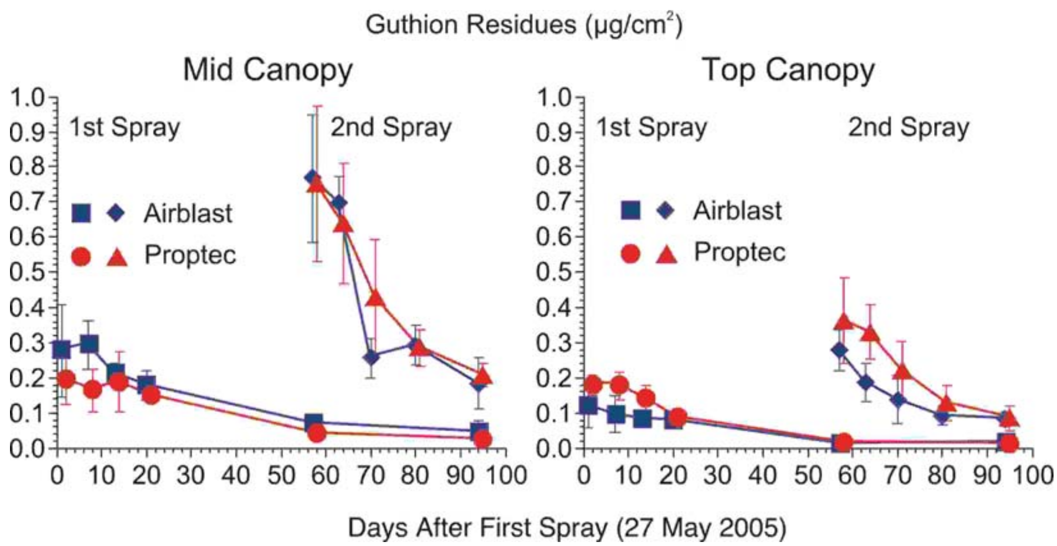

Figure 4. Effect of sprayer (Airblast vs. Proptec) on Guthion residue (µg/cm^2) deposition and decline on apples collected from the mid and top canopy levels during crop year 2004 at the H&M Orchard. Symbols represent the mean residue recovered (n=6), and the error bars represent the 95% confidence interval for the mean. Overlapping error bars indicate that residues recovered from different treatments (i.e., sprayer type and day of collection) are not significantly different (p = 0.05).

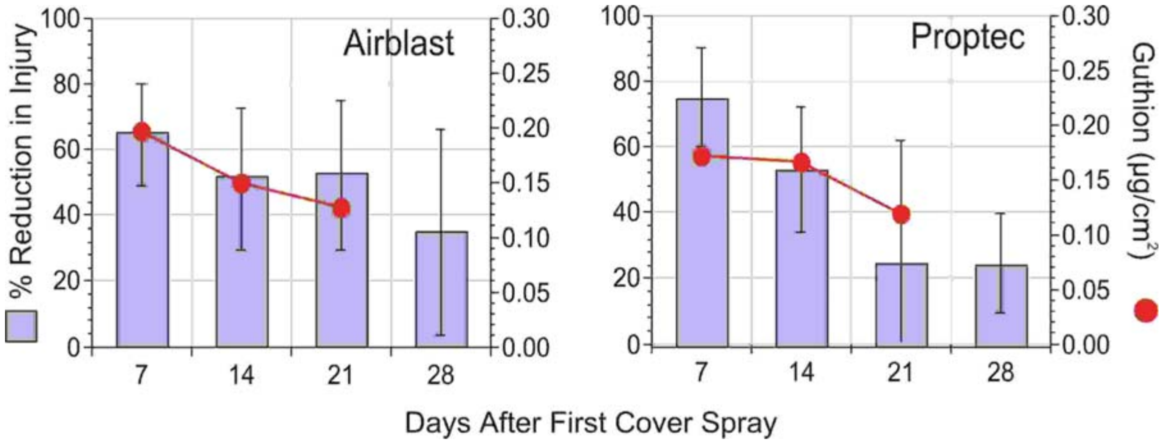

Figure 5. Percent reduction in apple injury (stings + entry holes) determined from laboratory assays on apples collected during 2004 at the H&M Orchard (shown as shaded bars). Guthion residues (µg/cm^2) on apples collected at the same time periods are shown as circle symbols and represent the average of residues determined for the mid and top level of the canopy. The vertical error bars represent the 95% confidence interval for the mean % reduction in injury from neonate codling moth (CM). Overlapping error bars indicate that injury reduction among days is not significantly different (p = 0.05).

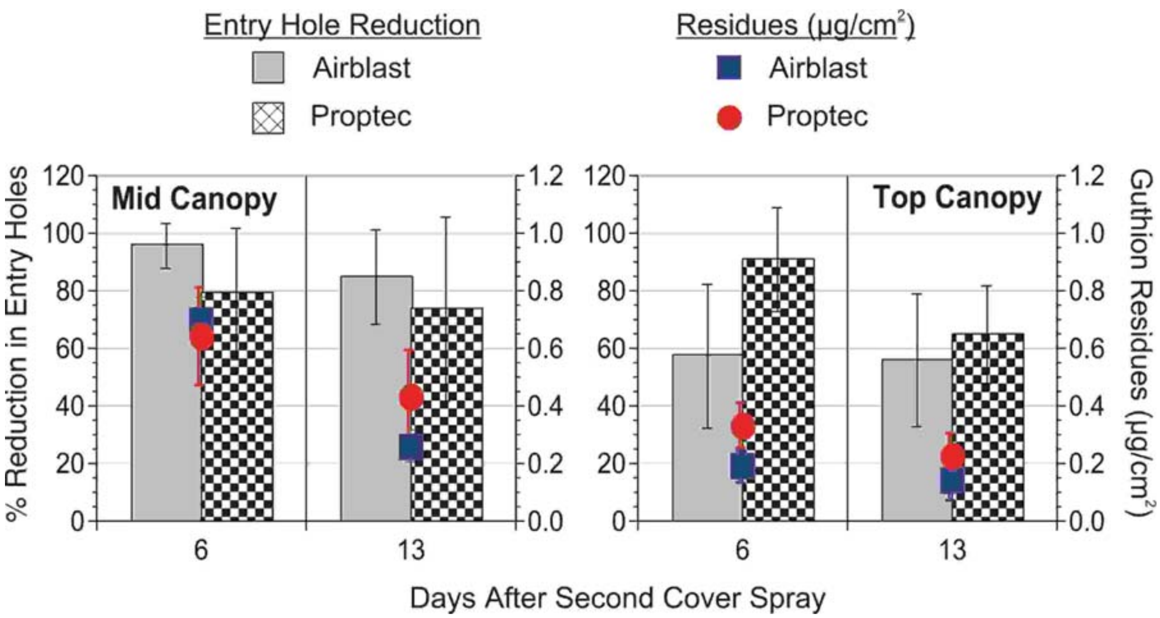

Figure 6. Percent entry hole reduction in laboratory bioassayed field sprayed apples compared to untreated apples collected during 2004 from the H&M Orchard. Gray and patterned bars represent the mean % entry hole reduction (n=6); symbols represent the residues (µg/cm^2) recovered from apples corresponding to the day of bioassay; vertical error bars represent the 95% confidence interval for the mean. Overlapping 95% CI indicate that entry hole reduction and residues are not significantly different (p = 0.05).

Table 1. Guthion residues on Gala apples collected from the H&M Orchard on August 29, 2004, a date comparable to commercial harvest in the lower Yakima Valley.

Sprayer	**No. of Sprays (Days After Application)**	**Mid Canopy Residues µg/g (95% Confidence Interval)**	**Top Canopy Residues µg/g (95% Confidence Interval)**
Airblast	1 (94)	0.038 (0.010, 0.066)	0.014 (0.010, 0.019)
Proptec	1 (94)	0.019 (0.011, 0.028)	0.007 (0.005, 0.009)
Airblast	2 (37)	0.152 (0.091, 0.214)	0.068 (0.052, 0.085)
Proptec	2 (37)	0.172 (0.144, 0.200)	0.070 (0.041, 0.099)