Objectives
The objective of this project was to conduct a field study with insecticides commonly used for control of spotted wing drosophila (SWD), and fungicides commonly used for Botrytis blight and fruit rot, that would determine pesticide residue levels of blueberry fruit samples at various days after treatment. With such information, a pest management spray regime and use pattern could be developed that results in residue levels acceptable to international trade partners.

Impacts and Benefits of this Project
Blueberry growers continue to face the challenges of effective pest management in their fields while also attempting to develop a pesticide spray program that will allow them to ship fruit to foreign markets. The arrival of SWD has caused blueberry growers to make more insecticide applications than ever before, with those applications needing to be close to harvest and, in some situations, between harvests. Fungicide applications are also often needed close to harvest and between harvests. As with any commodity, residue levels of blueberry fruit must be below the allowable Maximum Residue Limit (MRL) for a given country, otherwise the shipment can be rejected. Knowing how close to harvest a pesticide can be used without the risk of an MRL violation will help growers develop a pest management strategy and choose the most favorable pesticides for their particular export market. The results of this 3-year study provide the guidance growers need to make prudent pest management decisions, and allow Oregon blueberry exporters to preserve and expand their export markets without fear of an MRL violation.

Methodology
Field trials were conducted in Oregon in a field of 9-year old blueberry plants (Vaccinium corymbosum; cultivar ‘Bluecrop’) located at OSU’s Lewis-Brown Research Farm in Corvallis, OR, to determine pesticide residue levels of 17 different active ingredients found in pesticide products commonly used by Oregon blueberry growers. Experimental design was a randomized complete block with four replications of 8-plant plots for each treatment. The blueberry planting consisted of plants in rows 10 feet apart, with plants spaced 2.5 feet apart within the row.

Treatments were applied with a CO₂ backpack sprayer equipped with a 3-nozzle boom (TeeJet 8002vs) at 40 psi, delivering 75 gal/A water, with the spray solution directed to both sides of each plant row in two passes. All treatments were mixed with non-chlorinated well-water from the Lewis-Brown Research Farm; the tank mix solutions were well mixed and agitated prior to, and during, application. The planting was maintained using standard and customary weed control and fertilizer. All plots were drip-irrigated two to three times per week, delivering about one to two inches of water per week.

In 2015, application to Treatment #3 was made on 18 Jun; all other treatments, including Treatment #3, received an application on 25 Jun. Approximately one pound of mature, ripe fruit was sampled at 1, 4, 9, 13, 17, and 21 days after the 25 June application, changing gloves between treatments to reduce risk of contamination. After each sample was harvested, it was placed in a zip-lock plastic bag and put into a cooler with blue ice in the field. After the last sample on each sample date was
completed, the samples were transported to, and placed in, a freezer within 20 minutes. Although exact dates are different, treatment applications and sample harvests for the Oregon trials in 2013 and 2014 were similar to methods described for 2015.

Similar studies, using the same field research protocol that included the same 13 insecticides, rates, number of applications, spray interval, etc., were conducted in Washington and Michigan. Alan Schreiber (eastern WA), and Lynell Tanigoshi and Steve Midboe (northwestern WA) each conducted one field trial in Washington in 2013, 2014, and 2015; Rufus Isaacs conducted one field trial in Michigan (East Lansing), in 2014 and 2015. All samples were analyzed at Synergistic Pesticide Laboratory in Portland, OR. However, cultivar, plant age, application method, plot size, and spray volume varied from site to site. Treatments 1 and 3 included the same pesticides in the tank mix but Treatment 3 included two applications, one week apart, whereas Treatment 1 had just one application. Only the Oregon site included the fungicide treatment.

This report summarizes data from all sites in all three states for 2013, 2014, 2015.

Treatment Parameters - 2015

<table>
<thead>
<tr>
<th>TRT #</th>
<th>Active Ingredient</th>
<th>Product Name and Formulation</th>
<th>Rate (lb a.i./A)</th>
<th>Rate (product/A)</th>
<th>No. of Apps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bifenthrin</td>
<td>Brigade 2EC</td>
<td>0.1</td>
<td>6.4 fl oz</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Imidacloprid</td>
<td>Admire Pro</td>
<td>0.1</td>
<td>2.8 fl oz</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Malathion</td>
<td>Malathion 8Flowable</td>
<td>2.5</td>
<td>40 fl oz</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Methomyl</td>
<td>Lannate LV</td>
<td>0.9</td>
<td>48 fl oz</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Spinosad</td>
<td>Entrust SC</td>
<td>0.1</td>
<td>6 fl oz</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Zeta cypermethrin</td>
<td>Mustang Max</td>
<td>0.025</td>
<td>4 fl oz</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Carbaryl</td>
<td>Sevin 4F</td>
<td>2.0</td>
<td>2 qt</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Cyantraniliprole</td>
<td>Exirel</td>
<td>0.088</td>
<td>13.5 fl oz</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Esfenvalerate</td>
<td>Asana</td>
<td>0.05</td>
<td>9.6 fl oz</td>
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</tr>
<tr>
<td></td>
<td>Fenpropathrin</td>
<td>Danitol</td>
<td>0.3</td>
<td>16 fl oz</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Phosmet</td>
<td>Imidan 70W</td>
<td>1.0</td>
<td>1.33 lb.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Spinetoram</td>
<td>Delegate</td>
<td>0.9</td>
<td>6 oz</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Thiamethoxam</td>
<td>Actara</td>
<td>0.06</td>
<td>4 oz</td>
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</tr>
<tr>
<td>3</td>
<td>Bifenthrin</td>
<td>Brigade 2EC</td>
<td>0.1</td>
<td>6.4 fl oz</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Imidacloprid</td>
<td>Admire Pro</td>
<td>0.1</td>
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<td>2</td>
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<tr>
<td></td>
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<td>Mustang Max</td>
<td>0.025</td>
<td>4 fl oz</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Cyprodinil + fludioxonil</td>
<td>Switch</td>
<td>0.55</td>
<td>14 oz</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Boscalid + pyraclostrobin</td>
<td>Pristine</td>
<td>0.54</td>
<td>23 oz</td>
<td>1</td>
</tr>
</tbody>
</table>
Insecticides

Bifenthrin:
~ Residues meet MRLs for Australia, Japan, and Taiwan at 1-day PHI.
~ For Korea, if wait 3 days, 60% of samples are < 0.3 ppm; if wait 16 days, 90% are < 0.3 ppm and meet Korean MRL.
~ Canada, Codex, EU, and Hong Kong: Do not ship to these markets.

Imidacloprid:
~ Residues meet MRL for all markets, except Australia (delay harvest until 14 days after application).
**Malathion:** Rapid decline of residues
~ Residues meet MRLs in Australia, Canada, Codex, Hong Kong, Japan, and Korea.
~ EU and Taiwan: Do not ship to these markets. Expanding the scale shows that 93% of the samples still had residues $>0.02$ ppm at 9 days.

**Methomyl:** Slow decline of residues
~ Residues meet MRL in Canada and Hong Kong
~ Japan and Korea: wait 4 days to harvest (50% of samples are $<0.02$ppm); if wait for 12 days (93% are $<0.02$ ppm).
~ Australia and Taiwan: wait 7 days to harvest.
~ Codex and EU: Do not ship to these markets.
Spinosad: Rapid decline of residues.
～ Residues meet MRLs for all countries.

Zeta-cypermethrin:
～ Residues meet MRLs in Korea and Taiwan
～ Australia and Japan: wait 3 days to harvest, then 100% of samples are < 0.5 ppm.
～ Canada, Codes, EU, and Hong Kong: Do not ship to these markets.
Carbaryl:
~ Residues meet MRL in Australia, Canada, and Japan.
~ For Korea and Taiwan, wait about 14 days (86% of samples are < 0.5 ppm).
~ EU and Hong Kong: Do not ship to these markets.

Cyantraniliprole:
~ Residues at the USA’s PHI of 3-days meet MRLs for most markets; even Korea at 0.7 ppm.
~ Hong Kong and Taiwan: Do not ship. These countries have not established an MRL for cyantraniliprole.
Esfenvalerate: Residues decline slowly.
  ~ Residues meet MRL in Australia, Japan, and Taiwan
  ~ Codex, EU, HK, and Korea: Do not ship to these markets

Fenpropathrin:
  ~ Residues meet MRLs in most markets.
  ~ For Korea, wait about 9 days (70% of samples < 0.5 ppm)
  ~ Australia, Codex, and EU: Do not ship to these markets.
Phosmet:
~ Residues meet MRLs in Australia, Canada, Codex, EU, HK, Korea, and Japan
~ For Taiwan: If wait 9 days, then 86% of samples have residues < 1.0 ppm.

Spinetoram:
~ Even with WA3’s unusually high residues in 2013, residues at the USA’s PHI of 3-days meet MRLs for all markets except Hong Kong.
~ Hong Kong: Do not ship. Hong Kong has not established a MRL for spinetoram.
Thiamethoxam:
~ Residues meet MRLs in Australia, Canada Codex, HK, Japan, Korea, and Taiwan
~ For EU: if wait 7 days to harvest then 86% of the samples are < 0.05 ppm.

**One Application vs. Two Applications of Insecticides**
The imidacloprid graph, below, is representative of the other pesticides that had two applications as one of the treatments. All had higher residues for each harvest date with two applications when compared to just one application, which is what would be expected.

**Imidacloprid**

<table>
<thead>
<tr>
<th>TRT 1 (1 app) &amp; TRT 3 (2 apps) Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phi</td>
</tr>
<tr>
<td>1 day</td>
</tr>
</tbody>
</table>

LOD = 0.01 ppm

**Two applications**
(Data not shown; see market information above for one application for each insecticide.)

**Imidacloprid and Malathion:** Residues from two applications of imidacloprid or malathion would allow fruit to be shipped to the same markets as those for which there was just one application.
**Spinosad:** Except for one site that had unusually high residues, two applications of spinosad would allow fruit shipments to the same markets as per one application.

**Zeta-cypermethrin:** If the two sites for which residues increased between one and three days (an unlikely natural event) are excluded from the data analysis, two applications of zeta-cypermethrin would allow fruit shipments to the same markets as per one application.

**Bifenthrin:** Market entry is the same for two applications as for one application of bifenthrin except for Korea. Residues remained above 0.3 ppm at several sites with two applications and, thus, fruit should not be shipped to Korea.

**Methomyl:** Residues with two applications of methomyl were high enough to change market entry. Unlike for one application, with two applications, one would need to wait 16 days to ship fruit to Australia and Taiwan without a risk of a MRL violation. For Japan and Korea, waiting 21 days would be necessary to ship fruit safely to those markets.

### Fungicides

- **Switch (cyprodinil + fludioxonil):**
  - Residues for cyprodinil at 1-day PHI meet MRLs for all countries except Hong Kong and Korea.
  - For Hong Kong, do not ship fruit to Hong Kong fruit sprayed with Switch, as there is no MRL established for cyprodinil and Hong Kong does not have a default policy, which means 0 ppm is allowed. For Korea, wait 2-3 days before shipping, then 100% of the samples are < 1.0 ppm for cyprodinil.
  - Residues for fludioxonil at 1-day PHI meet MRLs for all countries.
Pristine (boscalid + pyraclostrobin):
~ Residues for boscalid at 1-day PHI meet MRLs for all countries.
~ Residues for pyraclostrobin at 1-day PHI meet MRLs for all countries except Korea. For Korea, wait 2 days before shipping, then 100% of the samples are < 0.7 ppm for pyraclostrobin.

Discussion/Summary

The graphs in this report represent residue data from five locations (OR, MI, and three from WA) over a three year period. In addition, there was a mix of application methods and cultivars used at each location. This provides enough variability to mimic any conditions a grower might use in their own operation.

The decline curves for each of the active ingredients analyzed in this study present growers with a guide on how to use a particular pesticide for fruit destined for export markets. Knowing the MRL of a specific active ingredient for a specific export market, a grower will be able to decide on a harvest date after last application that will meet the MRL of a foreign market.

A few generalizations that can be made about the results of this study:

• Except for an occasional outlier, all residue levels in this study meet USA tolerance levels, which is what a grower would expect when following the USA label use directions and PHI.

• Most residue levels in this study acceptable in most markets. In some cases, delaying the harvest (longer PHI) is necessary in order to meet the MRL in a particular foreign market.

• EU, Hong Kong, and Korea are difficult markets to ship to: MRLs don’t exist for certain insecticides and fungicides in these countries, or the MRL is so low that they are not possible to achieve unless fruit harvest is delayed past the US preharvest interval.
• Some insecticides degrade rapidly in the field (e.g., malathion, spinosad, spinetoram).

• Some insecticides degrade slowly (e.g., esfenvalerate, methomyl).

• The US preharvest interval (PHI) for both Switch and Pristine fungicides is 0-day. Unfortunately, the first samples collected in this study occurred at 1-day PHI, mainly because 13 insecticides were also included in this study and none of them had a 0-day PHI. In hindsight, we should have collected samples for the fungicide treatments at 0-day PHI to match the labeled US preharvest interval.