Field Testing of Two Harvest Aids in Washington Apple Orchards

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WA State Tree Fruit Orchards
Seasonality in Apple Production

- Pruning
- Thinning
- Harvesting
- Sort, Grade, & Pack
- Other

ESD LMEA
Apple Harvest Employment
12 Billion times
Apple harvesting methods
1939

2011

72 years of innovation
Harvest aids tested in 2011

DBR Conveyor Concepts

Oxbo/Picker Technology

Van Doren Sales Inc.
Objectives

- 1) Evaluate design, function and durability of equipment under a wide range of apple varieties, harvest scenarios and orchard systems.

- 2) Identify where and what type of bruising occurs along the fruit handling system.

- 3) Measure human productivity and the overall efficiency of the operation.
Bruise Evaluation

<table>
<thead>
<tr>
<th>Shift</th>
<th>Bins Run</th>
<th>BinType &amp; Tare</th>
<th>Gross Lbs. Run</th>
<th>Peeler Wt.</th>
<th>Cull Wt.</th>
<th>Rot Wt.</th>
<th>Net Wt.</th>
<th>Peeler %</th>
<th>Cull%</th>
<th>Rot %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Time</td>
<td>19:00</td>
<td>27 WOOD</td>
<td>28746</td>
<td>3591</td>
<td>1890</td>
<td>0</td>
<td>25776</td>
<td>13.93%</td>
<td>7.33%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Finish Time</td>
<td>20:09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours Worked</td>
<td>1.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• Techmark IRD internal sensor: Tri-axial accelerometer, +/- 500 g (3% accuracy)
## DBR Impact Tests

<table>
<thead>
<tr>
<th>Bin Fill Position</th>
<th>Average number of impacts</th>
<th>Categories</th>
<th>Average number of impacts</th>
<th>Maximum $G_g$ ($\bar{x} / SD$)</th>
<th>Velocity change, m/s ($\bar{x} / SD$)</th>
<th>Duration, ms ($\bar{x} / SD$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bottom Third</strong></td>
<td></td>
<td>tubes</td>
<td>21.07</td>
<td>17.43 ± 9.29</td>
<td>1.48 ± 0.91</td>
<td>13.66 ± 6.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>decelerator</td>
<td>1.46</td>
<td>15.82 ± 7.29</td>
<td>1.55 ± 0.96</td>
<td>15.10 ± 8.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bin</td>
<td>1.29</td>
<td>16.37 ± 9.91</td>
<td>1.15 ± 0.53</td>
<td>11.33 ± 4.08</td>
</tr>
<tr>
<td><strong>Middle third</strong></td>
<td></td>
<td>tubes</td>
<td>19.45</td>
<td>17.31 ± 9.40</td>
<td>1.44 ± 0.95</td>
<td>13.55 ± 7.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>decelerator</td>
<td>0.87</td>
<td>16.40 ± 9.18</td>
<td>1.51 ± 0.97</td>
<td>14.00 ± 7.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bin</td>
<td>0.94</td>
<td>13.59 ± 6.19</td>
<td>1.12 ± 0.62</td>
<td>11.87 ± 5.41</td>
</tr>
<tr>
<td><strong>Top third</strong></td>
<td></td>
<td>tubes</td>
<td>20.21</td>
<td>17.38 ± 8.75</td>
<td>1.49 ± 0.91</td>
<td>14.03 ± 7.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>decelerator</td>
<td>0.49</td>
<td>12.65 ± 4.87</td>
<td>1.29 ± 0.93</td>
<td>14.96 ± 9.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bin</td>
<td>0.97</td>
<td>13.90 ± 5.84</td>
<td>1.04 ± 0.62</td>
<td>10.72 ± 4.86</td>
</tr>
</tbody>
</table>
DBR Impact Tests

- Impacts at bottom third
- Impacts at middle third
- Impacts at top third

Maximum acceleration (g)

0 - 10% bruise threshold

Velocity change (m/s)
OXBO Harvest assist machine
OXBO Harvest assist machine
Oxbo / Picker Tech Results: Bruising

- Impact bruising
  - Decellerator
  - J-conveyor
  - Bin filler

- Equipment damage
  - Decellerator
  - Bin filler

- Stem punctures
Results: Bruising

- Honeycrisp
- Fuji
- Red Del.
- Golden Delicious
# Delicious

<table>
<thead>
<tr>
<th></th>
<th>WA EXF</th>
<th>US EXF</th>
<th>Culls</th>
<th># of damaged fruit (%)</th>
<th>% of total damage</th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hand</strong>*</td>
<td>97</td>
<td>2</td>
<td>1</td>
<td>17</td>
<td>97</td>
<td>91</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td><strong>Machine</strong></td>
<td>94</td>
<td>5</td>
<td>1</td>
<td>18</td>
<td>96</td>
<td>71</td>
<td>24</td>
<td>4</td>
</tr>
</tbody>
</table>

* 2% punctures
Results: Productivity and Efficiency

- **Orchard design**
- **4 people crew**
- **Delicious:**
  - 6 bins/hr. = 10 min/bin
  - 13-27min currently
  - range in picking speed:
    - 20-62 pc/min
Capacity: 1 apple/sec/tube \rightarrow 4 apples/sec/tube

Minutes per bin/ 4 pickers per bin

<table>
<thead>
<tr>
<th></th>
<th>Tops Only DBR</th>
<th>Tops Only Ladder</th>
<th>Whole Tree DBR</th>
<th>Whole Tree Ladder</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18:05</td>
<td>27:15</td>
<td>23:55</td>
<td>25:38</td>
</tr>
<tr>
<td>2</td>
<td>18:15</td>
<td>24:23</td>
<td>21:63</td>
<td>18:49</td>
</tr>
<tr>
<td>3</td>
<td>19:30</td>
<td>23:51</td>
<td>22:57</td>
<td>25:45</td>
</tr>
<tr>
<td>4</td>
<td>19:57</td>
<td>24:34</td>
<td>23:35</td>
<td>26:40</td>
</tr>
</tbody>
</table>

DBR - 5.25% cullage due to bruising / cuts 87% WA and US XFancy

Ladder/ Bag – 4.50% cullage due to bruising / cuts 91% WA and US XFancy
Challenges/ Modifications

DBR

- Increase picking speed
- Orchard systems/cropload
- Lighting
- Tractor driver
- Exhaust
- Improve ergonomics
  - Tube position and inlet
  - Platform

Oxbo/Picker Technology

- Increase picking speed
- Orchard systems/cropload
- Improve ergonomics
  - Tube length
  - Injury potential
  - Halter design
- Eliminate bruising in Decelerator
- Consistency
Simple, Narrow and Productive (SNAP)
Our Present
Our Future
Thank You!

DBR Conveyor Concepts LLC.
Oxbo International Inc.
Picker Technologies
USDA NIFA SCRI “CASC”
Washington Tree Fruit Research Commission
Ruilong Lou
Cooperating Orchards and their employees