Evaluation of Automated Thinners for Lettuce Production

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There has been interest in the development of mechanical thinners for sugar beets for many years. Efforts at UC Davis go back to 1900. Culminated by a design developed by Roy Garrett, published in 1966. There were many other designs developed by many researchers in many parts of the country and by grower/fabricators. Early designs did not use plant detection technology.
<table>
<thead>
<tr>
<th>Method</th>
<th>Man hours per acre</th>
<th>Yield in tons per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete mechanical thinning</td>
<td>2.45</td>
<td>12.24</td>
</tr>
<tr>
<td>Modified mechanical thinning plus long-handed hoe</td>
<td>11.6</td>
<td>11.40</td>
</tr>
<tr>
<td>Long-handled hoe thinning</td>
<td>15.6</td>
<td>11.47</td>
</tr>
<tr>
<td>Customary hand block and thin</td>
<td>27.2</td>
<td>12.17</td>
</tr>
</tbody>
</table>

Colorado State University, 1943
A Big Leap Forward with Computer Processing of Camera Images
The Tillet Machine by Garford Corp (England) uses spinning blades that spin around the desired plant.
• The idea of using a spray to remove unwanted plants was developed in sugar beets and showed advantages over mechanical thinning devices:
  ▪ Less inertia
  ▪ Fewer moving parts
  ▪ More precision

Fig. 2. Hydraulic and pneumatic circuits

Cox and McLean, 1969
Spray Removal of Plants

• The wedding of spray removal of unwanted plants and computer image processing is a new development

• It is rapidly developing and four companies now have machines
  ▪ Ag Mechtronix
  ▪ Blue River Technology
  ▪ Ramsey Highlander/Oraka
  ▪ Vision Robotics

Mark Siemens, U of Arizona Field Day at USDA Spence Station 2011
Area treated with herbicide to remove plants

Area treated with herbicide to remove plants
Spray Material Options on Lettuce

- Registered on lettuce:
  - Glyphosate
  - Gramaxone
  - Scythe
  - Shark

- Fertilizers:
  - Salt based
    - AN20, UN32, Ammonium thiosulfate
  - Acid based
    - NpHuric

- Other materials
  - Sulfuric acid

- Organic herbicides
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- Organic herbicides
Thinning/Weeding Trial

• This trial was conducted under cool, moist conditions:
  ▪ Temperatures in the low 60’s and significant dew on the plants at time of application
## Thinning/Weeding Trial
### Plants Treated when 14 Days Old

<table>
<thead>
<tr>
<th>Control Material</th>
<th>Rate</th>
<th>Lettuce Control rating</th>
<th>Malva Control rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioLink Herbicide</td>
<td>12% v/v</td>
<td><strong>9.8</strong></td>
<td><strong>9.1</strong></td>
</tr>
<tr>
<td>Final San-O</td>
<td>20% v/v</td>
<td>3.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Weed Pharm</td>
<td>100% v/v</td>
<td>7.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Weed Zap</td>
<td>5% v/v</td>
<td>3.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Scythe</td>
<td>9% v/v</td>
<td><strong>8.1</strong></td>
<td><strong>6.5</strong></td>
</tr>
<tr>
<td>Shark</td>
<td>1.0 oz/A</td>
<td><strong>10.0</strong></td>
<td><strong>10.0</strong></td>
</tr>
<tr>
<td>NpHuric</td>
<td>20% v/v</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>14-0-0-5</td>
<td>20 gal/A</td>
<td><strong>8.1</strong></td>
<td><strong>4.0</strong></td>
</tr>
<tr>
<td>Untreated</td>
<td>---</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Conventional Materials

Scythe

Shark
Conventional Materials

NpHuric

14-0-0-5
Organic Materials

Bio Link Herbicide

Final San O
Organic Materials

Weed Pharm

Weed Zap
Registration of Thinning Materials

• It has taken nearly a year for the specific registration of Shark to wind its way through the registration process at the CDPR

• It is in the 30 day waiting period which should be completed by the end of this month

• Biolink is completing its registration as an organic herbicide and should be available before the end of this year
2014 Evaluations of Automated vs Hand Thinning

• Worked with cooperating growers that split fields: half were thinned with automated thinners and the other was hand thinned

• Seven fields were evaluated

• Thinners from three companies conducted the automated thinning (AgMechtronix, Blue River and Foothill Packing)
# Time to Thin and Time to Weed & Remove Doubles

<table>
<thead>
<tr>
<th>Method</th>
<th>Thinning hrs/A</th>
<th>Weed/Double hrs/A*</th>
<th>Total Time hrs/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated</td>
<td>0.9</td>
<td>6.6</td>
<td>7.5</td>
</tr>
<tr>
<td>Hand</td>
<td>6.6</td>
<td>5.3</td>
<td>11.9</td>
</tr>
</tbody>
</table>

*Automated thinning probably took more time because it left more doubles than hand thinning:

Automated: 1,024 plants/A  
Hand: 148 plants/A
## Evaluation of Thinning

<table>
<thead>
<tr>
<th>Method</th>
<th>Mean plant spacing inches</th>
<th>Percent plants within 9-11 inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated</td>
<td>10.3</td>
<td>71.1</td>
</tr>
<tr>
<td>Hand</td>
<td>10.5</td>
<td>57.0</td>
</tr>
</tbody>
</table>
Automated thinning tended to cluster around the desired spacing (10 in.) more precisely than hand thinning.
## Impact on Weeds and Sclerotinia

<table>
<thead>
<tr>
<th>Method</th>
<th>Weed Control Percent</th>
<th>Sclerotinia Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated</td>
<td>69.9</td>
<td>4.4</td>
</tr>
<tr>
<td>Hand</td>
<td>72.6</td>
<td>4.0</td>
</tr>
</tbody>
</table>
## Yield Comparison

<table>
<thead>
<tr>
<th>Method</th>
<th>Total Yield Boxes/A</th>
<th>Head Weight lbs/head</th>
<th>Unharvested Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated</td>
<td>1099</td>
<td>1.95</td>
<td>4.4</td>
</tr>
<tr>
<td>Hand</td>
<td>1046</td>
<td>1.96</td>
<td>5.4</td>
</tr>
</tbody>
</table>
Further Observations

• Although we did not measure the difference in the size of the plants left by automated vs hand thinning, we noted at times that auto thinning would take out larger plants and leave smaller plants
• In hand thinning, this was mostly not the case
• We conducted evaluations to determine if this was of any consequence
Growth Evaluation of Small vs Larger Plants at Thinning

- At harvest:
  - Small 330.6 grams/plant
  - Large 475.5 grams/plant

- Smaller plants left at thinning do not catch up with larger plants
Summary

• Automated thinners using spray technology to remove unwanted plants is a powerful new technology for production of direct seeded lettuce

• The spray materials that are or will soon be available are highly effective

• Automated thinners are more precise than hand thinning

• There is no adverse impact on yield; in fact there is some evidence that yield may be higher

• Challenges that remain include
  – Removal of double
  – Selection of larger plants at thinning may help improve the yield advantage of automated thinning
Acknowledgements

• Cooperating growers
• Automated thinner companies
• Fabian Galvan and Tricia Love, Research Assistants