Intra-row Cultivation & Lettuce thinning

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Constraints on Specialty Crop Weed Program Improvement

- Economic and regulatory constraints on the pesticide industry.
- Insufficient public and industry resources dedicated to develop non-pesticide technology for pest control in specialty crops.
- The major machinery manufactures are not very interested in specialty crops.
Integrated Weed Management in Vegetables

- Strategies and tactics for IPM
  - Prevention
  - Sanitation
  - Field selection
  - Physical weed management
  - Cultural weed management
  - Chemical weed control

http://www.ipm.ucdavis.edu/
Integrated Weed Management in Lettuce

181,300 weeds/A
Kerb (pronamide) $50/A

99,700 weeds/A
Cultivate $56/A

37,600 weeds/A
Hand weed $138-230/A

0 weeds/A

Tourte & Smith 2010
Fennimore et al. In press
A traditional inter-row cultivator does not reach into the seedline.

An intra-row cultivator weeds around and in the row.
Robotic Thinning/Weeding Objectives

- Determine if we can thin and weed lettuce with the rotating cultivator
- Determine if the need for hand weeding and thinning can be reduced with the rotating cultivator
- Measure rotating cultivator effects on lettuce yields
Garford Robocrop Cultivator

http://www.thtechnology.co.uk/index.html
Lettuce Thinning with the Rotating Cultivator

Before thinning

After thinning
Data & Analysis

- Weed densities measured before & after cultivation
- Hand thinning & weeding times were measured
- Analyzed as split-plot: cultivators, & herbicides
## Post Cultivation Weed Densities in Seeded Lettuce

<table>
<thead>
<tr>
<th>Cultivator</th>
<th>Trial 1</th>
<th>Trial 4</th>
<th>Trial 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotating</td>
<td>66 b</td>
<td>19 b</td>
<td>45 b</td>
</tr>
<tr>
<td>Standard</td>
<td>140 a</td>
<td>37 a</td>
<td>65 a</td>
</tr>
</tbody>
</table>
## Thinning Times in Seeded Lettuce

<table>
<thead>
<tr>
<th>Cultivator</th>
<th>Trial 1</th>
<th>Trial 4</th>
<th>Trial 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotating</td>
<td>14.4 b</td>
<td>10.6 b</td>
<td>9.1 b</td>
</tr>
<tr>
<td>Standard</td>
<td>20.8 a</td>
<td>12.5 a</td>
<td>14.2 a</td>
</tr>
</tbody>
</table>

**Time (hr/A)**
### Post Cultivation Lettuce Stands in Seeded Lettuce

<table>
<thead>
<tr>
<th>Cultivator</th>
<th>Trial 1</th>
<th>Trial 4</th>
<th>Trial 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotating</td>
<td>70 b</td>
<td>67 b</td>
<td>84 b</td>
</tr>
<tr>
<td>Standard</td>
<td>89 a</td>
<td>94 a</td>
<td>110 a</td>
</tr>
</tbody>
</table>

Stand (no. 100/ft)
## Yields Seeded Lettuce

<table>
<thead>
<tr>
<th>Cultivator</th>
<th>Trial 1</th>
<th>Yield</th>
<th>Prod. costs</th>
<th>Net returns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Crtns/A</td>
<td>$/A</td>
<td></td>
</tr>
<tr>
<td>Rotating</td>
<td>943 b</td>
<td>398</td>
<td>10,069</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>1,068 a</td>
<td>479</td>
<td>11,376</td>
<td></td>
</tr>
</tbody>
</table>
# Bok Choy – Santa Maria

<table>
<thead>
<tr>
<th>Cultivator</th>
<th>Weeds</th>
<th>Thin time</th>
<th>Stand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotating</td>
<td>1,000/A</td>
<td>14 b</td>
<td>18 a</td>
</tr>
<tr>
<td>Standard</td>
<td>28 a</td>
<td>17 a</td>
<td>105 a</td>
</tr>
</tbody>
</table>
Robotic Thinning Studies - Conclusions

- The rotating cultivator reduces stand & yields too much
- The precision needed in seeded lettuce is lacking
- The rotating cultivator reduces hand thinning time
- This cultivator works in transplanted lettuce
In row weeding in transplanted lettuce

- Conducted at the Salinas USDA station in 2009 & 2010.
- Plots were 2 X 40-inch wide beds wide by about 80 ft long. RCBD with 4 reps
- Treatments were the rotating cultivator and the standard cultivator and Kerb at 0 and 1.2 lb ai/A.
- Weed control is based on the difference between pre and post cultivation counts.
## Weed densities & weeding times in transplanted lettuce

<table>
<thead>
<tr>
<th>Cultivator</th>
<th>Trial 2</th>
<th>Trial 6</th>
<th>Trial 2</th>
<th>Trial 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotating</td>
<td>2 b</td>
<td>51 b</td>
<td>5.4 b</td>
<td>10.8</td>
</tr>
<tr>
<td>Standard</td>
<td>11 a</td>
<td>93 a</td>
<td>6.1 a</td>
<td>11.3</td>
</tr>
</tbody>
</table>
## Yield of marketable heads transplanted lettuce

<table>
<thead>
<tr>
<th>Cultivator</th>
<th>Trial 2</th>
<th>Yield</th>
<th>Prod. costs</th>
<th>Net returns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Crtns/A</td>
<td>$ /A</td>
<td></td>
</tr>
<tr>
<td>Rotating</td>
<td>528</td>
<td>360</td>
<td>5,501</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>553</td>
<td>307</td>
<td>5,831</td>
<td></td>
</tr>
<tr>
<td>P value</td>
<td>0.61</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Transplanted lettuce studies - conclusions

- The rotating cultivator removed more weeds than a standard cultivator but hand weeding was not reduced much.
- The rotating & standard cultivator yields were similar.
Machine costs

- The rotating cultivator cost is about $15-20K per plant line.
- An 8 plant line unit able to cultivate 4 lettuce beds would be $120-160K.
# Standard vs. Alternative Lettuce Weed Management Strategies

<table>
<thead>
<tr>
<th>Method</th>
<th>Initial Weeds</th>
<th>Kerb $50/A</th>
<th>Cultivate $56/A</th>
<th>Hand weed $138-230/A</th>
<th>Remaining Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicide</td>
<td>181,300</td>
<td>120,000</td>
<td>10,000</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cultivate</td>
<td>120,000</td>
<td>10,000</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Hand weed</td>
<td>10,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**Total weed cost = $250**
LETTUCE THINNING – INTERMITTENT SPRAYERS
Lettuce Thinning- Intermittent Sprayers
Thinning trial Treatments

- Scythe 7% v/v (7 gallons/100 gallons mix)
- AN 20 75% v/v (75 gallons/100 gallons mix)
- Sulfuric acid 10% v/v (10 gallons/100 gallons mix)
- 40-inch twin row beds, 660 ft long
# Machine lettuce thinning results

2012 Fennel Ranch, Salinas

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Pre thin No./A</th>
<th>Post thin No./A</th>
<th>Thin time Hr./A</th>
<th>Hand weed Hr./A</th>
<th>Total time Hr./A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower std</td>
<td>167,129</td>
<td>30,253</td>
<td>4.6</td>
<td>2.8 *</td>
<td>7.4</td>
</tr>
<tr>
<td>Machine</td>
<td>169,272</td>
<td>34,343</td>
<td>1.2</td>
<td>5.7</td>
<td>6.9</td>
</tr>
</tbody>
</table>
Thinning trial yield

- Standard grower yield 27.1 tons/A
- Machine thinned yield 25.1 tons/A which was significant
- Grower hand thinning costs were $92/A
- Machine thinning costs were $132/A for 1.5 mph.
- Net returns for grower standard $11,877 vs $10,953 for machine thinned
Lettuce thinning

- Need much faster operating speeds for lettuce thinner >1.5 mph.
- Optimize seed spacing at planting to take advantage of the technology
- Need to optimize use of labor – eg. Reduce number of hoe crew passes through the field from two to one.
Culticlean

- Is a propane fueled thermal pest control device from the Netherlands
- Heats the soil to about 176°F for a few seconds.
- Targets weed seeds and soil pathogens
Culticlean at Salinas, May 2013
High temperatures kill soil pests quickly.

Moderately high temperatures require more time to kill pests.

J. Noling 1997
Culticlean trial details

- Conducted at Spence USDA station at Salinas, CA.
- Initiated May 28, 2013
- The site was inoculated with Sclerotinia minor (lettuce drop) and overseeded with weeds.
- Replicated 4 times
Culticlean diagram
# Culticlean evaluation in lettuce May-Aug. 2013

<table>
<thead>
<tr>
<th>Cultivator</th>
<th>Ryegrass</th>
<th>Pigweed</th>
<th>Groundsel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culticlean</td>
<td>61 b</td>
<td>2 a</td>
<td>1 a</td>
</tr>
<tr>
<td>Control</td>
<td>87 a</td>
<td>1 a</td>
<td>2 a</td>
</tr>
</tbody>
</table>

Number (ft²)
Culticlean evaluation in lettuce May-Aug. 2013

<table>
<thead>
<tr>
<th>Cultivator</th>
<th>Lettuce drop</th>
<th>Head weight</th>
<th>Lettuce yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culticlean</td>
<td>10.3 b</td>
<td>2 a</td>
<td>37.4 a</td>
</tr>
<tr>
<td>Control</td>
<td>16.1 a</td>
<td>2 a</td>
<td>32.9 a</td>
</tr>
</tbody>
</table>
Culticlean conclusions

- Some reduction in lettuce drop and weeds
- Possible increase in lettuce yield
- The temperature dwell time needs to be increased
- Insulation
Acknowledgments

- David Fountain, Solex
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