Organic Weed Control in Vegetable Production Systems

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Introduction

• Controlling weeds in organic vegetable systems requires the use of many techniques and strategies.

• Weeds can always be pulled or cut out, but the question is simply how economical are the weed control operations.
Recent cost studies documenting weeding costs in organically produced broccoli and leaf lettuce

- Sample costs to produce organic broccoli
- Sample costs to produce organic leaf lettuce

http://www.agecon.ucdavis.edu/outreach/crops/cost.htm

- go to CEMonterey and go to the publication links
Comparison of Organic vs Conventional Leaf Lettuce Production Costs

<table>
<thead>
<tr>
<th>System</th>
<th>Costs $/A</th>
<th>Percent of Growing Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic¹</td>
<td>257</td>
<td>8</td>
</tr>
<tr>
<td>Conv.²</td>
<td>132</td>
<td>5</td>
</tr>
</tbody>
</table>

¹ Tourte and Smith, 2004; ² Tourte and Smith, 2001
## Comparison of Organic vs Conventional Broccoli Production Costs

<table>
<thead>
<tr>
<th>System</th>
<th>Weed Costs $/A</th>
<th>Percent of Growing Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic¹</td>
<td>270</td>
<td>9</td>
</tr>
<tr>
<td>Conv.²</td>
<td>161</td>
<td>8</td>
</tr>
</tbody>
</table>

¹ Tourte and Smith, 2004; ² Smith et al. 2004
• Any reduction in weeds and in the amount of weed seed or perennial propagules reaching the soil will make subsequent weed control operations less expensive.

• It is therefore useful to explore ways in which weed infestations come about.
SOIL SEEDBANK

• Pathogens
• Deep burial
• Environment

GERMINATION

(PHYSIOLOGICAL DEATH
(Outside & inside field dispersal)

PREDATION

FAILED GERMINATION
Aerially dispersed weed seed, can invade from outside the field, doesn’t reside in the seedbank.
Non-aerial dispersed seed that rains down onto the soil surface and resides for many years in the soil seedbank.
• Weeds require water, nutrients and light. They rob these from the crop
• The goal is to utilize production practices to provide an opportunity for the crop to gain an advantage over the weeds
• If successful, it allows the crop to outcompete and reduce the availability of resources to the weeds. If the use of various organically acceptable techniques can give the crop a competitive advantage, subsequent hand weeding operations and costs can be minimized.
Organically Acceptable Techniques

• Cultural Practices
  – Managing the Weed Seedbank
    • Sanitation (reducing seed set, or seed sources)
    • Carrying weeds (seed) out of field
  – Fooling Weed Seeds (manipulating weed seed germination)
    • Pre-germination
    • Stale bed
    • Seed capping
    • Planting to moisture
    • Buried drip irrigation

– Crop Competition
– Cover Crops - Eric
Weeds Around Edge of Field

Source of weed infestation
Purslane in bags carried to edge of field
Effects of preirrigation of listed beds on weed emergence in subsequent lettuce crop

No preirrigation                              Preirrigation

Can reduce weed emergence in subsequent cash crop by up to 50%
Pre germination
Stale Bed Technique: Pre-germinate and kill flush of weeds on shaped beds, prior to planting cash crop
Capping Seedlines
Planting to Moisture
Buried Drip Irrigation
Cover Crops and Weeds
Organically Acceptable Techniques

• Cultivation
  – Deep Plowing
  – Close Cultivation
  – Frequency of cultivation (kill weeds prior to seed set) – can eliminate perennial weeds
  – Cultivation Technology
    • Lazar guided cultivators
    • Various cultivators capable of removing weeds from the seedline of tough stemmed crops
    • Computer assisted weeders (not yet available)
Plowing (burying weed seed)
Close Cultivation
Cultivated Zone

Uncultivated Zone 4” wide

Cultivated Zone – 80% of the bed
4” wide cultivation strip
3” wide cultivation strip
Typical cultivation sled for the 2\textsuperscript{nd} cultivation of lettuce
Brush Hoe
Brush hoe 2.9 inch strips

After and before
Conventional

Brush Hoe
## Comparison of Brush Hoe and Conventional Cultivation

<table>
<thead>
<tr>
<th></th>
<th>Brush Hoe</th>
<th>Conventional Cultivator</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeds/ft Of row</td>
<td>12.9</td>
<td>27.3</td>
<td>14.4</td>
</tr>
<tr>
<td>% Weed Control</td>
<td>60.7</td>
<td>38.4</td>
<td>22.3</td>
</tr>
<tr>
<td>Hours/Acre to Weed</td>
<td>15.8</td>
<td>19.9</td>
<td>4.1</td>
</tr>
</tbody>
</table>
Brush Hoe Summary

• Brush hoe is capable of cultivating close (2 7/8” wide strip) to seedline with no adverse effects on the crop

• The machine we used was slower than conventional cultivator (2.5-3 vs 4-5 mph) and required two people to operate
Flex Tined Cultivator
More effective on tough-stemmed crops
Eco Dan Lazar Guided Cultivator

Fits between tractor and Cultivation sled
Sliding adjustment mechanism
Robotic Weed Control Concept

- Real-time weed sensing
  - Minimum Objectives
    - 3 km/h travel speed
    - 3 mm diameter weed detection.
  - Robust to real-world conditions.
    - Wind, rain delays,
    - Blemished plants

- Real-time weed control
  - Minimum Objectives
    - 1 cm² control area
    - Conventional & Organic compatible
Organic – Hot Oil Microspray

- Canola oil heated to 177 °C
- Sprayed only on weeds
Organically Acceptable Techniques

- **Flaming**
  - Used to kill weeds following preirrigation
  - Can be used preemergence on slow germinating crop such as pepper and others
  - Works better on small broadleaf seedlings
Flamed direct seeded peppers

Emerging pepper seedlings
Organically Acceptable Techniques

• Biofumigation
  – Mustard cover crops

• Soil sterilization
  – Solarization
  – Steam sterilization
  – Other natural agents
Impact of “Biofumigation” by Mustard Cover Crops on Weeds

White Mustard ‘IdaGold’
Indian Mustard

Indian Mustard ‘ISCI 61’
Why Mustard Cover Crops

- Produce a class of chemicals known as glucosinolates
- These materials break down enzymatically to isothiocyanates, thiocyanates, nitriles and isonitriles in the soil which are toxic to nematodes, fungi and weed seeds – biofumigation
- There may also be soil microbiological effects as well
2003 – 04 Mustard Rotational Cover Crop Plot

- 1st year of cover crop established in the fall of 2003
- Two crops of head lettuce grown in 2004
  - Evaluations of Sclerotinia and weeds conducted
- 2nd year of cover crop currently growing
## Mustard Cover Crop Rotational Plot

### Weed Evaluations on First Lettuce Crop

<table>
<thead>
<tr>
<th>Cover Crop Treatment</th>
<th>Lambs-quaters</th>
<th>Burning Nettle</th>
<th>Total Weeds</th>
<th>Cover Crop Biomass T/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merced Rye</td>
<td>2.8</td>
<td>1.8</td>
<td>9.4</td>
<td>3.1</td>
</tr>
<tr>
<td>Broccoli CC</td>
<td>12.9</td>
<td>7.2</td>
<td>26.3</td>
<td>1.3</td>
</tr>
<tr>
<td>White Mustard</td>
<td>2.7</td>
<td>2.9</td>
<td>8.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Indian Mustard</td>
<td>4.3</td>
<td>2.6</td>
<td>10.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Bare Fallow</td>
<td>4.3</td>
<td>1.3</td>
<td>8.5</td>
<td>-</td>
</tr>
</tbody>
</table>

March 4, 2004
Other Mustard Trials Cover Crop Trials
# Short-term Rotational Trials

## Weed Evaluations

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mustard CC</td>
<td>71.3</td>
<td>29.2</td>
<td>29.1</td>
<td>57.3</td>
<td>46.7</td>
</tr>
<tr>
<td>Bare Fallow</td>
<td>86.8</td>
<td>50.0</td>
<td>104.8</td>
<td>100.3</td>
<td>85.5</td>
</tr>
</tbody>
</table>

* Reductions in stand were observed
Solarization
Organically Acceptable Techniques

• Mulches
  – Colored plastic mulches
  – Organic mulches
Colored mulches
Organic mulch
(cowpea residue in Coachella)
Organically Acceptable Techniques

• **Beneficial organisms**
  - Weeder geese, sheep, etc.
  - Soil micro organism consume weed seed and seedlings
Shepherd’s Purse Seedbank Densities to 1 foot depth
Fennimore and Jackson, 2003

Seed/kg soil

Amend*  No Amend  Amend  No Amend
Minimum tillage  Conventional Tillage

* Cover crop and compost
Organically Acceptable Techniques

• Chemical control
  – Organic herbicides - Benny
    • Contain oils (i.e. clove and thyme), citric acid, acetic acid
    • Generally expensive, but may have a use as selective herbicides over the top of cole crops and onions
## 2004 Onion Weed Control Comparison

### Untreated vs Standard Conventional

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total Weeds per 4 ft²</th>
<th>Crop Damage</th>
<th>Hours/A to Weed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>28.5</td>
<td>0.0</td>
<td>48.4</td>
</tr>
<tr>
<td>Standard Chemical</td>
<td>0.5</td>
<td>1.0</td>
<td>1.3</td>
</tr>
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</table>
2003 Green Onion Evaluation

Xpress at 20%
(Clove & Thyme Oils)
in 35 gals/A on
green onions
Over the Top Application of Xpress Organic

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Material per Acre</th>
<th>Crop Damage</th>
<th>Broadleaf Weed Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Un treated</td>
<td>----</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Xpress @ 10%</td>
<td>3.5 gals</td>
<td>0.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Xpress @ 20%</td>
<td>7.0 gals</td>
<td>1.9</td>
<td>7.5</td>
</tr>
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Summary of Organically Acceptable Weed Control Systems

• There are many and varied techniques available to manage weeds in organic systems
• They do continue to be an expensive production input in organic vegetables
• Cultural practices however remain critical to reducing weed pressure
Summary of Organically Acceptable Weed Control Systems

- The situation with weed control in organic crops has changed in the last 10 years
- The availability of high technology cultivation equipment and organic herbicides are useful new tools
- In the future, computer assisted in-row weeding may prove useful, but initial costs may be high