Extending Your Growing Season with High Tunnels and Biodegradable Mulches

Annette Wszelaki
Commercial Vegetable Specialist
Topics to Cover

• Maximizing your tunnel for profit
• Beyond yield in tunnels
• New crop for tunnels
• Biodegradable mulches
Maximizing Your Tunnel for Profit
Potential Sales from a 30’ x 96’ Spring Planted High Tunnel

Before we look at potential sales, there are a few things to keep in mind:

- Your expertise (or lack thereof!)
- Your market and your marketing skills
- Fertility of your high tunnel
- Weather patterns
- Staying on top of plant management—
  - Irrigation, weed control, insect control, trellising, suckering

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Lay-out for 30’ wide high tunnel using wide beds

- Beds against the side walls are 30” wide with 3 rows of drip tape 8” spacing starting at 9” in from toe-board
- All aisle ways are 15” wide (for those with big feet!)
- There are 5 – 42”-wide beds with 4 rows of drip tape on 10-1/2” spacing, starting 5” in from edge of aisle or
- You can lay 5 rows of drip tape on 9” centers, starting 4” in from the edge of the aisle

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
<table>
<thead>
<tr>
<th>Bed</th>
<th>Width</th>
<th>Aisle Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>42 in</td>
<td>15 inches wide</td>
</tr>
<tr>
<td>#2</td>
<td>42 in</td>
<td>15 inches wide</td>
</tr>
<tr>
<td>#3</td>
<td>42 in</td>
<td>15 inches wide</td>
</tr>
<tr>
<td>#4</td>
<td>42 in</td>
<td>15 inches wide</td>
</tr>
<tr>
<td>#5</td>
<td>42 in</td>
<td>15 inches wide</td>
</tr>
</tbody>
</table>

Outside Bed Along Toeboard – 30 inches wide
Calculating Potential Profit per Crop

• \((\text{Row feet} \times \text{rows of drip tape})/\text{in-row spacing} = \# \text{ of units of crop (heads of lettuce, carrots, beets, tomatoes, etc.)}\)

• \((\# \text{ of units} \times \% \text{ harvestable} \times \# \text{ of harvests})/\text{quantity for market bundle} = \# \text{ of market bunches}\)

• \(# \text{ of market bunches} \times \text{price per bunch} = \text{Potential \$\$\$ per crop}\)
Examples:

**Beets:**
(24 row feet x 6 rows (3 rows of drip tape, plant a row on either side))/1.5” (0.125’) in-row spacing = 1,152 beets

(1,152 beets x 80% harvestable x 1 harvest)/6 beets/bunch = 150 bunches

150 bunches x $1.50 per bunch = $225.00

150 bunches x $3.00 per bunch = $450.00

**Options:** Make 2 plantings about 2 to 3 weeks apart to spread out harvest giving you 25 bunches a week for 6 weeks.
Examples:

**Swiss Chard:**

\[(24 \text{ row feet} \times 3 \text{ rows of drip tape})/8” (0.66’) \text{ spacing} = 108 \text{ plants}\]

\[\frac{108 \text{ plants} \times 2 \text{ leaves per plant per week} \times 100\% \text{ harvestable} \times 8 \text{ weeks (harvests)}}{16 \text{ leaves per bunch}} = \sim 14 \text{ bunches/week for 8 weeks or 112 bunches}\]

\[112 \text{ bunches} \times $1.50 \text{ per bunch} = $168.00\]

\[112 \text{ bunches} \times $3.00 \text{ per bunch} = $336.00\]
Examples:

**Tomatoes:**
90 row feet x 1 row drip x 22” (1.83’) spacing = 50 plants

50 Bush Early Girl x 3.5 pounds/week x 80% marketable x 3 weeks per plant = 420 lbs

420 lbs x $2.50 per lb = $1,050.00

420 lbs x $4.00 per lb = $1,680.00

24 assorted cherry plants x 5 weeks x pint per plant per week = 120 pints

120 pints @ $2.50 per pint = $300.00

120 pints @ $4.00 per pint = $480.00
Potential Sales from a 30’ x 96’ Spring Planted High Tunnel

Remember, there are a few things to keep in mind:
• Your expertise (or lack thereof!)
• Your market and your marketing skills
• Fertility of your high tunnel
• Weather patterns
• Staying on top of plant management-
  • Irrigation, weed control, insect control, trellising, suckering

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Many thanks to Paul and Alison Wiediger for generously sharing their slides and insight!

http://aunatureelfarm.homestead.com/
Beyond Yield: Quality of Hybrid and Heirloom Tomatoes Using High Tunnels

Mary A. Rogers, Dean A. Kopsell and Annette L. Wszelaki
Methods

– Three replicates grown in high tunnels and in open field plots, managed organically
– Pre-plant with mushroom compost (124 lbs of N/acre) and fertigate with fish emulsion (3.5 lbs of N/acre)
Varieties

Heirlooms

‘Arkansas Traveler’

‘Cherokee Purple’

‘Valencia’

Hybrids

‘BHN 589’

‘Fletcher’

‘Primo Red’

Quality Assessment

Tested three vine-ripe, marketable fruit per plot from the third fruit cluster from the bottom of the plant

- Skin color
- Firmness
- Soluble solids
- Titratable acidity
- Lycopene content
Results: Firmness

Analysis was done using Mixed Models ANOVA (SAS 9.3); \( \alpha = 0.05 \)
Results: Firmness

Analysis was done using Mixed Models ANOVA (SAS 9.3); $\alpha = 0.05$

Comparison of planting dates:
- March: b
- April: a
- May: a

$p = .0251$
Results: Soluble Solids

Analysis was done using Mixed Models ANOVA (SAS 9.3); $\alpha = 0.05$

$\text{High Tunnel}$

$\text{Open Field}$

$p = 0.0002$
# Results: Lycopene

<table>
<thead>
<tr>
<th>Variety</th>
<th>High Tunnels</th>
<th>Open Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas Traveler</td>
<td>2.67 d</td>
<td>3.47 cd</td>
</tr>
<tr>
<td>BHN 589</td>
<td>3.39 cd</td>
<td>3.75 bcd</td>
</tr>
<tr>
<td>Cherokee Purple</td>
<td>7.07 a</td>
<td>4.42 bc</td>
</tr>
<tr>
<td>Fletcher</td>
<td>4.93 b</td>
<td>2.86 d</td>
</tr>
<tr>
<td>Primo Red</td>
<td>2.80 d</td>
<td>1.32 e</td>
</tr>
<tr>
<td>Valencia</td>
<td>0.00 f</td>
<td>0.00 f</td>
</tr>
</tbody>
</table>

## Analysis

- TRT\(p = .0032\)
- VAR\(p < .0001\)
- TRT*VAR\(p = .0018\)

Analysis was done using Mixed Models ANOVA (SAS 9.3); \(\alpha = 0.05\)  (Data reported for 2009 only)
Baby Ginger

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Transplanted on June 17th – about 3 weeks late!

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
First top dressing and hilling
July 5th

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
July 5th after first hilling

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Clump
July 31st

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
September 29th

First harvest

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Harvest from 6 row feet on September 29th

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Ginger
October 11th

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Clump October 11th

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Harvest from December 10th

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Ginger Production – Key Points

• Pre-sprout before planting
• Hungry crop – needs both food and water
• Soil temps between 55 and 90 degrees F
• Needs to be hilled – 2 or better yet, 3 times
• Top dress when hilling
• Water deep before it gets dry – at least 2X per week
• In warmer climates will need shading

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Ginger available from Hawaiianorganicginger.com

Slide courtesy of Paul and Alison Wiediger, Au Naturel Farm
Many thanks to Paul and Alison Wiediger for generously sharing their slides and insight!

http://aunaturelrfarm.homestead.com/
Do biodegradable mulches have a place in your production system?

Annette Wszelaki¹, Jennifer Moore¹, Carol Miles² and Shuresh Ghimire²

¹Department of Plant Sciences, University of Tennessee
²Department of Horticulture, Washington State University

This material is based upon work that is supported by the National Institute of Food and Agriculture, under award number 2014-51181-22382. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Benefits of Plastic Mulch

- Weed management
- Reduces some diseases and insect pests
- Warms soil in spring
- Increases yield
- Reduces erosion
- Hastens time to harvest

- Conserves moisture
- Increases crop quality
- More efficient use of water and fertilizer
- Reduces soil compaction
- Efficient double or triple cropping
Problems with Plastic Mulch

- Need for removal and disposal
- Disposal cost is $145-236/ac (Galinato et al., 2012)
- Generally not all plastic is removed
- Issue of sustainability
- Decrease soil productivity, water quality
- Overall environmental hazard
Biodegradable Plastic Mulch

Has the potential to be a sustainable technology if it:

• Provides equal benefits as plastic mulch
• Reduces labor costs for removal and disposal
• Reduces landfill waste
• Completely biodegrades
• Causes no harm to soil ecology or environment
What does biodegradable mean?

- Capable of being broken down via microbial activity
- Complete biodegradation (i.e., mineralization) refers to the oxidation of the compound to carbon dioxide and water
- Biodegradation provides carbon as a source of food for the growth and reproduction of microorganisms

Source: Numata, 2009
Biodegradable: Microbial activity that results in CO₂, H₂O and microbial biomass

Biobased: Feedstocks derived from renewable resources (plant and/or animal mass) via biological processes

Biobased ingredient that doesn’t biodegrade in soil: PLA¹

Synthetic ingredients that biodegrade in soil: PCL, PBS, PBAT

¹ Probably would degrade over 10+ years if thin enough; passes ASTM/ISO compostability standard
Biobased Content

Feedstocks derived from renewable resources (plant and/or animal mass) via biological processes

- Certified biobased by measuring level of $^{14}$C, indicates recent fixation via photosynthesis
- ASTM D6866

USDA NOP memo July 24, 2015

- Report by OMRI, June 5, 2015: current biodegradable mulch films contain 10-20% biobased feedstock
- Remaining content includes polymers derived from fossil fuels, dyes, mineral and in some cases heavy metals
Effective October 30, 2014, final rule added **biodegradable biobased mulch film** to list of allowed substances (USDA organic regulation 7 Code of Federal Regulations section 205)

- To be considered biobased and biodegradable, a mulch film MUST:
  1. Be biobased ASTM D6866
  2. Reach ≥ 90% biodegradation in soil within 2 years ISO 17556 or ASTM D5988
  3. Meet compostability specifications of ASTM D6400, ASTM D6868, EN 13432, EN 14995, or ISO 17088

- Must be produced without organisms or feedstock derived from excluded methods (i.e., synthetic, GMO)

- Must be produced without the use of non-biobased synthetic polymers; minor additives (colorants, processing aids) not required to be biobased
What are we lacking?

- Better understanding of biodegradation of commercially available mulches in different climates
- Information on mulch accumulation after multiple applications
- Technology to measure mulch biodegradation in soil
- Good agriculture practices to hasten mulch biodegradation
Performance and Adoptability of Biodegradable Plastic Mulch for Sustainable Specialty Crop Production

Funded by USDA-NIFA through Specialty Crop Research Initiative (SCRI)

Experiments at Knoxville, TN and Mount Vernon, WA

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USDA SCRI BDM Project

• Evaluate impacts of repeated use on agricultural soil ecosystem (soil quality, microbial communities, carbon storage)

• Identify degradation mechanisms and interrelationships among life-cycle stages: fossil fuel-derived or biobased, role of weathering, soil degradation or composting

• Evaluate degradation in diverse climates to improve performance and evaluation methods

• Compare results of lab-scale standardized tests for biodegradability and weathering with results from field studies

• Identify potential crop weed, disease and insect pest problems
USDA SCRI BDM Project (contd)

- Identify supply chain steps with focus on economic relevance and feasibility, regulation, and farmer’s perceptions to elucidate bridges and barriers to adoption

- Educate farmers, intermediaries, consumers and the general public on BDMs, biodegradation, and biobased plastics

- Interact with consumers, farmers, intermediaries, regulators, composters, and scientists to increase interest in sustainable use of BDMs

- Educate and train students, research associates, and scientists on skills needed to work on transdisciplinary research problems
Project Design

• Two locations: Knoxville, TN & Mount Vernon, WA
• ‘Cinnamon Girl’ pie pumpkin
• 30 ft plots of 5 rows each, replicated 4 times
• Seeded direct: 15 June Knoxville
• Transplanted: 28 & 29 May Mount Vernon
• Harvested: 14 Sept. Knoxville
  16 Sept. Mount Vernon
• Eight treatments
# Mulch Products in Experiment

<table>
<thead>
<tr>
<th>Trt.</th>
<th>Mulch Product</th>
<th>Company</th>
<th>Width (In.)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bare ground</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Polyethylene plastic</td>
<td>FilmTech Corp.</td>
<td>48</td>
<td>0.0254</td>
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<tr>
<td>3</td>
<td>Weed Guard</td>
<td>Sunshine Paper Co.</td>
<td>48</td>
<td>0.24</td>
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<tr>
<td>4</td>
<td>BioAgri</td>
<td>BioBag USA</td>
<td>48</td>
<td>0.018</td>
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<tr>
<td>5</td>
<td>Naturecycle</td>
<td>Custom Bioplastics</td>
<td>48</td>
<td>0.0254</td>
</tr>
<tr>
<td>6</td>
<td>Organix</td>
<td>BASF/Organix Ag.</td>
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<td>0.0177</td>
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<td>7</td>
<td>Experimental</td>
<td>Metabolix</td>
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<td>0.0381</td>
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<tr>
<td>8</td>
<td>BioAgri Removed</td>
<td>BioBag USA</td>
<td>48</td>
<td>0.018</td>
</tr>
</tbody>
</table>
2015 Preliminary PVD

Percent Visual Deterioration (PVD)

Knoxville

Mount Vernon

BioAgri
Metabolix
Naturecycle
Organix
PE
WeedGuardPlus
2015 Preliminary Yield

Knoxville

Mount Vernon
Mulch Adhesion
2015 Preliminary Mulch Adhesion

Knoxville

Mount Vernon
Preliminary Data: TN Weeds

Number of weeds (per m²)

- Bareground
- Bioagri
- Metabolix
- Naturecycle
- Organix
- PE
- Weedguard

Dates:
- 7-Jul
- 29-Jul
- 31-Aug
Predominant weeds in TN:
1. Nutsedge
2. Carpetweed
3. Goose grass
4. Annual bluegrass
5. Crabgrass

Predominant weeds in WA:
1. Pigweed
2. Chickweed
3. Grass (assorted)
Mulch Soil Incorporation
Soil Sampling BDM Post Tillage
Collecting BDM
Measuring BDM Area

1. Graph paper
2. Photo Image J
3. Weight
Acknowledgements

**Project Team** USDA SCRI Project No. 2014-51181-22382

**TN:** Douglas Hayes (Project Director), Annette Wszelaki, Jennifer DeBruyn, Sean Schaeffer, Susan Schexnayder, Arnold Saxton, Larry Wadsworth, Margarita Velandia, Mark Fly, Sreejata Bandopadhyay, Nurul Farhana Omar, Marie English, Kelly Cobaugh, Jennifer Moore

**WA:** Markus Flury, Carol Miles, Debra Inglis, Thomas Marsh, Jessica Goldberger, Chris Benedict, Peter Tozer, Suzette Galinato, Jeremy Cowan, Craig Cogger, Andy Bary, Lydia Tymon, Shuress Ghimire, Henry Sintim, Ed Scheenstra, Babette Gunderson, Jacky King, Amy Salamone

**MT:** Eric Belasco

For more information: [www.biodegradablemulch.org](http://www.biodegradablemulch.org)
Thank you!

Questions?

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