Winter Production in High Tunnels

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Winter Vegetables

- Lettuce (head and mixes)
- Asian and other greens
- Spinach
- Parsley
- Spring onions
- Kale
- Collards
- Poc choi
- Radish
- Turnips
- Chard
- Celery
- Herbs
Heat Sources

- Solar energy (light and heat)
  - Insolation, regional and site
  - Greenhouse orientation
- Ambient heat of the earth
Effects of Structure Design on Thermal Performance

- Gothic arch shape
- Relationship of perimeter to surface area
- Perimeter ground insulation
- Use of interior covers
- Types of films and coverings
- Interior layouts
- Gable end layout and ventilation
Passive Solar Greenhouse (March, Zone 6)
Ken Dawson’s high tunnel late winter (zone 7A)
Inner Covers Closed for the Night
Jan. 1997 (weekly min. -7 degrees F. zone 6 PA)
Two Different Demonstration High Tunnels at CEFS SFU

- **Warm high tunnel**
  - Two layers of poly film roof covering
  - Perimeter insulation
  - Insulated (polycarbonate) gable ends

- **Cool high tunnels**
  - Single layer of roof covering
  - No perimeter insulation
  - Single layer poly film gable ends
Effects of various inner covers on Poc Choi planted in a winter production high tunnel

- With 6 mil plastic inner cover
- With Typar inner cover (upper)
- With no cover (lower)
Effects of various inner row covers on greens planted on the same day and grown in a winter production high tunnel (top to bottom; 6 mil plastic, Typar, no cover)
Number of Days to First Harvest of Cut Greens (Jan-Feb. 2007)

Various Types of High Tunnels and inner Covers

- Warm, Warm, plastic typar
- Warm, no plastic typar
- Cool, plastic typar
- Cool, no plastic typar
- Cool, no cover

Estimated Number of Days to Harvest:
- Warm, Warm, plastic typar: 25 days
- Warm, no plastic typar: 30 days
- Cool, plastic typar: 35 days
- Cool, no plastic typar: 40 days
- Cool, no cover: 45 days
Days to Second Harvest of Lettuce Mix Under Various Types of High Tunnels and Inner Covers

Type of High Tunnel and Inner Cover

- Warm, plastic
- Warm, typar
- Warm, no cover
- Cool, plastic
- Cool, typar
- Cool, no cover
High tunnels were 20’ x 36’ with 6’ extended height sides, roll up sides, engineered for hurricane force winds.

Approximate Cost for the cool tunnel was $3000 ($4.10/sq ft)

Warm high tunnel cost an additional $980 or ~32% more.

30’ x 96’ costs ~$8,500 ($2.95/sq ft)
Basic gross revenue from lettuce mix

- The Demonstration tunnel configuration can produce 508 oz/week of lettuce mix
- Price of Earth bound Mixed Baby Greens $3.59/5 oz bag (10/10/07) $364 gross/week/tunnel
- Price of store brand lettuce mix $3.39/6 oz bag (10/10/07) $287 gross/week/tunnel
Observations from 2007 Winter Greens Production

- "Heavyness" makes an economic difference (Tatsoi is slightly heavier than Misuna and both are twice as heavy as Lettuce Mix)
- Days to harvest make an economic difference (Lettuce is much slower to grow in cooler environments)
- Mixed greens may provide a marketing option to combine taste (sale ability) and lbs per square foot.
Materials and Methods

- Planted September 19, 2006; Salisbury, NC.

- Plant spacing; double rows on raised beds; 18” between plants in rows; rows 12” apart.

- Followed standard strawberry plasticulture management recommendations except for fertigation schedule.

- Weekly fertigation at 5# actual N/ acre rate began week of planting and later upped to 7# based on leaf analysis.
Materials and Methods

- Plastic cover removed from the tunnel after Jan. 25, and plants “rested” for about five weeks.

- Plastic cover replaced on March 1, 2007, and weekly fertigation resumed.

- Spring (extended season) harvests began April 7 and continued through June 4 (8 weeks).
Materials and Methods

- Medium weight row covers (1.5 oz.) were placed over the rows in the tunnel during cold periods and were very effective in preventing loss of flowers and fruit.

- Relied on wind and air movement for pollination.

- First off-season harvest took place Nov. 22, 2006, and weekly harvests continued through Jan. 25, 2007 (10 weeks).
RESULTS
Table 2. First Full Season Marketable Yields of Strawberry Varieties in a High Tunnel, Salisbury, NC. 2006/2007

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plastic Mulch</th>
<th>Marketable Yield (g/plant)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fall/Ewinter²</td>
<td>Spring³</td>
</tr>
<tr>
<td>Albion</td>
<td>White</td>
<td>220.5</td>
<td>597.7</td>
<td>800.2</td>
</tr>
<tr>
<td></td>
<td>Black</td>
<td>197.0</td>
<td>692.0</td>
<td>889.0</td>
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<tr>
<td>Araza</td>
<td>White</td>
<td>224.0</td>
<td>510.7</td>
<td>734.7</td>
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<tr>
<td></td>
<td>Black</td>
<td>266.5</td>
<td>653.4</td>
<td>919.9</td>
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<tr>
<td>Carmine</td>
<td>White</td>
<td>129.0</td>
<td>332.1</td>
<td>461.1</td>
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<tr>
<td></td>
<td>Black</td>
<td>71.7</td>
<td>296.3</td>
<td>368.0</td>
</tr>
<tr>
<td>Chandler</td>
<td>White</td>
<td>191.2</td>
<td>1068.4</td>
<td>1259.6</td>
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<tr>
<td></td>
<td>Black</td>
<td>160.0</td>
<td>920.9</td>
<td>1080.9</td>
</tr>
<tr>
<td>Seascape</td>
<td>White</td>
<td>219.7</td>
<td>683.3</td>
<td>903.0</td>
</tr>
<tr>
<td></td>
<td>Black</td>
<td>191.9</td>
<td>647.5</td>
<td>839.4</td>
</tr>
<tr>
<td>Straw. Festival</td>
<td>White</td>
<td>428.5</td>
<td>551.6</td>
<td>980.1</td>
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<tr>
<td></td>
<td>Black</td>
<td>338.9</td>
<td>602.6</td>
<td>941.5</td>
</tr>
<tr>
<td>Sweet Charlie</td>
<td>White</td>
<td>303.2</td>
<td>322.8</td>
<td>626.0</td>
</tr>
<tr>
<td></td>
<td>Black</td>
<td>271.9</td>
<td>483.9</td>
<td>755.8</td>
</tr>
<tr>
<td>Winterdawn</td>
<td>White</td>
<td>94.6</td>
<td>538.2</td>
<td>632.8</td>
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<tr>
<td></td>
<td>Black</td>
<td>107.2</td>
<td>370.3</td>
<td>477.5</td>
</tr>
</tbody>
</table>

¹Conditioned plug plants except Albion and Seascape; planted 09/19/2006.
³Harvest period 04/10/2007 – 06/04/2007 (8 weeks).
Summary

Fall/early winter production:

- No differences between white/black and black plastic mulch for any variety.

- Percent marketable fruit was very high.

- ‘Strawberry Festival” on white/black mulch had the highest total and marketable yield per plant.

- ‘Albion’ produced the largest fruit, but fruit size was good for all but ‘Winterdawn’, and ‘Carmine’ on black plastic.
Summary

Fruit characteristics:

- ‘Strawberry Festival’ was equal to or better than all other varieties.

- ‘Seascape’ had the best flavor, though not statistically better than ‘Strawberry Festival’ or ‘Chandler’.

- ‘Sweet Charlie’ had pale skin color and unacceptably white flesh color.

- ‘Araza’ and ‘Winterdawn’ were only acceptable for flavor.
Strawberries, Nov. 13
Soxx filled with organic compost
Tomato Cumulative Total Yield - CEFS 2007

Yield (lbs/rep)

- Tunnel
- Field
Conclusions

- Grafting provides a site-specific management tool for soilborne disease.
  - Bacterial Wilt (*Ralstonia solanacearum*)
  - Fusarium Wilt (*Fusarium oxysporum* f.sp. *lycopersici*)
  - Root-knot Nematodes (*Meloidogyne* spp.)
  - Verticillium Wilt (*Verticillium dahliae* (race 2))
  - Southern Stem Blight (*Sclerotium rolfsii*)
- Grafting may affect nutrient uptake efficiency.
- ~25 days early season extension with high tunnels.
- Total productivity was higher in the tunnel system.
- Beaufort and Maxifort show higher yields under no soilborne disease pressure.
- Optimal planting date is March 20th for Eastern NC.
Importance of Variety Selection
Cold growth difference between Outredgious (L) and Oscarde (R) lettuce
Effects of Salinity in Greenhouse Pepper Production (2003)
High: 3.89 dS/m, Medium: 2.51 dS/m, Low: 0.85 dS/m
Insectary Crops
Biological control of Aphids
Homemade high tunnels
4-square intensive planting
Maximizing Production

- Use well started transplants in open flats
- Close Plant spacings
  - 6” spacings give 621 plants/100 sq. ft., 8”-320 plants, 10”-201 plants, 12”-159 plants
- Interplanting
- 4 Square plantings
- Utilize pathways for transplant production and cut and come again greens production.
2003-2004 Thermal Performance of inner and outer covers in unheated Greenhouses standardized to outside for average temperatures mid December-mid February and for the average of five cold nights (zone 6)
# Growth height and harvest weights after 28 days

(Jan 18-Feb 15)

<table>
<thead>
<tr>
<th>Type of high tunnel</th>
<th>Inner Cover</th>
<th>Mizuna</th>
<th>Tatsoi</th>
<th>Salad Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Height (inches)</td>
<td>Weight (oz)</td>
<td>Height (inches)</td>
</tr>
<tr>
<td>Hot</td>
<td>Plastic</td>
<td>7</td>
<td>5.9</td>
<td>5.5</td>
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<tr>
<td></td>
<td>Typar</td>
<td>4.75</td>
<td>3.7</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>No cover</td>
<td>2.75</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Cool</td>
<td>Plastic</td>
<td>6.5</td>
<td>5.3</td>
<td>4.75</td>
</tr>
<tr>
<td></td>
<td>Typar</td>
<td>4.75</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>No cover</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>