Organic Strawberry Production in High Tunnels

M. Elena Garcia, Horticulture Professor, Ext Fruit and Nut Specialist
Taunya Ernst, Technician
Fruit Research Station
Strawberries: Great Outlook!

- Available year round
- Interest in locally produced food
- Health benefits
- Consumption increasing
- Cultivar improvements
- New types
- New production systems
Strawberry Consumption

Figure 17: U.S. Strawberry per Capita Consumption, 2000-2011

Source: Economic Research Service. USDA
History of Production

• Historically, Arkansas and surrounding region were one of the leading strawberry producing areas
• In 1926, there were 15,000 acres of the berries
• Today region produces less than 1% of total national production
• The rapid increase in the number of Farmers’ Markets in the region combined with increasing demand by consumers for local produce has created lucrative opportunities for growers of this highly sought after berry
The Plant

The strawberry plant is a non-woody perennial:

- Crown
- Leaves
- Fruit truss
- Stolons- runners
- Root system
Leaves

- Compound pinnate and trifoliate
  - Three leaflets
  - Each leaflet has its own petiolule attached to leaf stem
    - petiole
  - Live a few months
Stolons

• Each stolon (runners) can produce new stolons
• “Mother” plant can transfer water, nutrients, and assimilates to “daughter” plant from several weeks to years
Strawberry Morphology

• Roots- from the base of leaves on the crown
  – primary roots live for up to one year
  – 50-90% of roots are in the upper 6" of the soil
Photoperiod

• The developmental responses of plants to the relative lengths of the light and dark periods
  – timing of both the light and dark periods
Photoperiod

- Strawberry cultivars vary greatly in the expression of repeat flowering
- Strawberry cultivars traditionally have been classified into photoperiodic response groups for flowering
Strawberry Flowering Types

• Short-day (SD) plants
  – Initiate flowers when photoperiod <14 hr
  – Chandler, Festival

• Day neutral (DN)
  – Photoperiod-insensitive varieties
  – photoperiods 9 to 16 hrs
  – Albion, Seascape

• Long-day plants (LD)
  – Require photoperiods > 12hrs
  – Not commercially important
Buying Plants

• Plants grown in colder climates - Canada

Tips- from runners

Plugs-live
Plants in colder climates

Bare root- dormant plants
Buying Plants

• Always start the planting with healthy, **virus-indexed** plants obtained from a reputable nursery

• Remember that disease-free plants are not necessarily disease resistant: cultivar selection determines disease resistance.

![Strawberry mild yellow edge](image)
Selecting Cultivars

• Flowering type
  – SD, DN
• Disease resistance
  – Fungal
• Plant availability
  – Plant stock
• Markets
  – Flavor
  – Shelf life
<table>
<thead>
<tr>
<th>Variety</th>
<th>LSc</th>
<th>LSp</th>
<th>LB</th>
<th>RS</th>
<th>PM</th>
<th>VW</th>
<th>AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albion</td>
<td>U</td>
<td>I</td>
<td>U</td>
<td>R</td>
<td>I</td>
<td>R</td>
<td>I</td>
</tr>
<tr>
<td>Allstar</td>
<td>T-R</td>
<td>S-T-R</td>
<td>S</td>
<td>R-VR</td>
<td>T-R</td>
<td>I-T-R</td>
<td>VS</td>
</tr>
<tr>
<td>Annapolis</td>
<td>S</td>
<td>S</td>
<td>U</td>
<td>T-R</td>
<td>S</td>
<td>S</td>
<td>U</td>
</tr>
<tr>
<td>Cavendish</td>
<td>R</td>
<td>R</td>
<td>U</td>
<td>R</td>
<td>U</td>
<td>T-R</td>
<td>U</td>
</tr>
<tr>
<td>Chandler</td>
<td>U</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>U</td>
<td>VS</td>
</tr>
<tr>
<td>Clancy</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Darselect</td>
<td>T</td>
<td>S</td>
<td>U</td>
<td>S</td>
<td>R</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Earliglow</td>
<td>R</td>
<td>S-I-R</td>
<td>S</td>
<td>I-R</td>
<td>S-I-R</td>
<td>I-T-R</td>
<td>S</td>
</tr>
<tr>
<td>Evie II</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>U</td>
</tr>
<tr>
<td>Honeoye</td>
<td>T-R</td>
<td>S-T-R</td>
<td>U</td>
<td>S</td>
<td>S-I</td>
<td>S</td>
<td>U</td>
</tr>
<tr>
<td>Jewel</td>
<td>R</td>
<td>R</td>
<td>U</td>
<td>S</td>
<td>T</td>
<td>S</td>
<td>U</td>
</tr>
<tr>
<td>Kent</td>
<td>I-R</td>
<td>S-R</td>
<td>U</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>U</td>
</tr>
<tr>
<td>L'Amour</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Lateglow</td>
<td>T-R</td>
<td>T-R</td>
<td>S</td>
<td>R</td>
<td>S</td>
<td>R-VR</td>
<td>U</td>
</tr>
<tr>
<td>Mesabi</td>
<td>T</td>
<td>T</td>
<td>U</td>
<td>R</td>
<td>U</td>
<td>R</td>
<td>U</td>
</tr>
<tr>
<td>Mira</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>R</td>
<td>U</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Northeaster</td>
<td>T</td>
<td>T</td>
<td>U</td>
<td>R</td>
<td>U</td>
<td>R</td>
<td>U</td>
</tr>
<tr>
<td>Ozark Beauty</td>
<td>U</td>
<td>R</td>
<td>U</td>
<td>S</td>
<td>U</td>
<td>S</td>
<td>U</td>
</tr>
<tr>
<td>Redchief</td>
<td>R</td>
<td>S-R</td>
<td>VS</td>
<td>R</td>
<td>S-R</td>
<td>I-R</td>
<td>VS</td>
</tr>
<tr>
<td>Sparkle</td>
<td>S-I</td>
<td>S-R</td>
<td>U</td>
<td>S-R</td>
<td>R</td>
<td>I-S</td>
<td>U</td>
</tr>
<tr>
<td>Tribute</td>
<td>T</td>
<td>T</td>
<td>U</td>
<td>R-VR</td>
<td>R</td>
<td>T-R</td>
<td>U</td>
</tr>
<tr>
<td>Tristar</td>
<td>T</td>
<td>T</td>
<td>U</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>U</td>
</tr>
<tr>
<td>AC Wendy</td>
<td>T</td>
<td>S</td>
<td>U</td>
<td>I</td>
<td>T</td>
<td>S</td>
<td>U</td>
</tr>
<tr>
<td>Winona</td>
<td>R</td>
<td>R</td>
<td>U</td>
<td>R</td>
<td>U</td>
<td>T</td>
<td>U</td>
</tr>
</tbody>
</table>

Key: VS = very susceptible, S = susceptible, I = intermediate, T = tolerant, R = resistant, VR = very resistant, U = unknown. Where multiple letter designations are given, ratings varied at different research sites.

The relative ratings in this chart apply to an average growing season. Under conditions favorable for disease development, any given variety may be more severely affected.

b. Varieties are not resistant to all races of the red stele pathogen.
Planting Date: Yield

Yield per Plant of Festival and Albion Day-Neutral Strawberries Planted in September or October under High Tunnel in Arkansas

- **Festival**
  - September: 120
  - October: 20

- **Albion**
  - September: 100
  - October: 10

*Graph showing yield comparison between Festival and Albion cultivars planted in September and October.*
• High risk for frost damage: Flowers and fruit can be damage at temp between 25 to 30 F
Minor cold crown damage

More extensive crown damage
Site Selection Considerations

• Soil type and structure
• Base soil fertility, nutrient level and pH
• Water drainage
• Elevation, slope and air flow (frost)
• Cropping history
• Existing vegetation
• Water supply
• Accessibility
• Presence of wildlife
• MARKETS!!!
Site Selection Considerations

• Strawberries - light-sandy soil with high organic matter and good water and air drainage
  – Avoid low-swampy areas with clay soil
    • Strawberries will not tolerate “wet feet”
  – Rocky ground provides good drainage but may be hard to work and establish adequate beds
Site Selection Considerations

• Asses soil nutrient levels….ASAP
  – Soil test
  – pH adjustment may take months or years
    • Apply lime or sulfur well before planting
  – Begin application of other soil amendments if necessary

• Existing vegetation
  – What species of weeds are present?
    • Cover cropping can help alleviate weed problems

• Soil fumigation
  – Biofumigation
Weed Control

- Prevention
- Mulch
- Mechanical
- Biological
- Organic Herbicides
Cover Crops and Solarization
# Allelopathic Cover Cops

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avena sativa</td>
<td>Oats</td>
</tr>
<tr>
<td>Brassica ssp.</td>
<td>Mustard, radish</td>
</tr>
<tr>
<td>Fagopyrum esculentum</td>
<td>Buckwheat</td>
</tr>
<tr>
<td>Hordeum vulgare</td>
<td>Barley</td>
</tr>
<tr>
<td>Melilotus spp.</td>
<td>Sweet clover</td>
</tr>
<tr>
<td>Secale cereale</td>
<td>Cereal or winter rye</td>
</tr>
<tr>
<td>Sorghum bicolor</td>
<td>Sorghum</td>
</tr>
<tr>
<td><em>Sorghum bicolor x S. sudanense</em></td>
<td>Sorghum-sudangrass hybrids</td>
</tr>
<tr>
<td>Sorghum sudanense</td>
<td>Sudangrass</td>
</tr>
<tr>
<td><em>Trifolium spp.</em></td>
<td>Clover: red, white, and subterranean</td>
</tr>
<tr>
<td><em>Triticum aestivum</em></td>
<td>Wheat</td>
</tr>
</tbody>
</table>
Organic Herbicides

- Only a limited number of organic herbicides are available
- Contact herbicides which are nonselective (similar to paraquat in activity)
- Weeds that are present at time of application are controlled - typically no soil activity
- Can be made more selective by manipulating timing and placement
Nutrition

• Based on soil and foliar and petiole analysis under field conditions
• 120 lb (actual N)/ acre in split application
  – 60 lb N pre-plant
  – The rest during growing season
• Based on foliar and petiole testing
  – U of A- $47.00
  – Six samples per season
Soil Analyses

Fig. 7. Soil pH in four different nitrogen treatments of “Strawberry Festival” strawberry grown under high tunnels

![Soil pH graph]

Fig. 8. Soil EC in four different nitrogen treatments of “Strawberry Festival” strawberry grown under high tunnels

![Soil EC graph]
Plasticulture Production

Advantages
• Higher yields: 2x higher than matted row
• Harvest earlier
• Extended harvest
• May double crop
• Better fruit quality – disease
• Quick turn-around time

Disadvantages
• Higher level of management
• Frost protection required
• Irrigation: Drip and overhead
• Cultivars used may not have enough resistance
• High investment costs
• Plastic use
Field Plasticulture
High Tunnel Plasticulture

• Advantages
  – Extended season
  – Can harvest regardless of weather
  – Dry fruit - less fruit rots??
  – Better fruit quality

• Disadvantages
  – High investment costs
  – Intensive management
  – Unpredictable production season
    • Weather
High Tunnel Plasticulture
Outside under covers – Mid-Feb 2014

Inside HT under covers - Mid-Feb 2014
High Tunnel Organic Research Fruit Research Station Clarksville, AR
Ground Preparations:

• The ground had been fallow ~ year, planted in a cover crop rotation
• Cover crop was cut, incorporated into the soil a month before plastic beds were formed

Added:

• 100 lbs of Organic+ (4-2-2)
• 12.2 lbs of Dolomitic lime
• 0.75 lbs/acre of boron was applied, and worked into the soil before beds were dug
Plot Establishment

- Four cultivars were used (Camarosa, Chandler, St. Festival, San Andreas)
- All plots were planted on Sept-24, a double row was used, with 1’ spacing
High Tunnel Management

• The tunnel sides were opened or closed in an attempt to maintain temperatures around 75°F (the recorded ideal growing temperature for strawberries)

• During cold days the sides of the tunnel would be open when the tunnel reached 50°F in attempt to “air” out the tunnel and hopefully reduce fungal pressure
Tunnel Management

• Row covers were pulled over strawberry beds when night temperatures dropped below 40°F

• On cloudy days, when temperatures did not rise above 45°F, plants remained covered all day

• On sunny days, or warm cloudy days, plants were uncovered
Tunnel Layout
Fertilizer

• Weekly fertigation was applied
• An organic, fish emulsion fertilizer was used (4-2-2)
• First application was the week after planting: 0.75lbs N/week
• Rate was increased to 1.0 lbs N/week on 14-Jan
Pest Management

• Actinovate was used to control powdery/Downey mildew.
  – During outbreaks Actinovate was sprayed every 7-10 days
• We rotated insecticide sprays between Neem oil, Stylet oil, and Bt but with little success
Pest Management (cont.)

• We introduced predatory lady beetle larvae to controlled the aphid population.

• To control the large mite population we used two different species of predatory mites:
  – *Neoseiulus californicus* was most effective.)
Gray Mold (Borytis)

- Common and serious strawberry diseases
- Ideal Conditions:
  - Rain, heavy dew, or overhead irrigation
  - Temperatures between 40 – 85 °F
- Exposure to 24+ hours of wet and warm temperatures will lead to 90% infestation
**Powdery Mildew**

- White patches on the lower leaf surface
- Rolled leaf edges
- Reddish-purple blotches on lower leaf surface
- Upper leaf surface: red speckling and purple discoloration
- Fruit may form white powdery substance
- Fruit is smaller
- Raised seeds and a lightly scarred surface
Miner Molds:

- Black seed diseases:
  - Same fungus as black leaf spot

- White mold:
  - No spray available
  - Remove plant and surrounding soil
APHIDS
## Results

<table>
<thead>
<tr>
<th></th>
<th>Camarosa</th>
<th>Chandler</th>
<th>St. Festival</th>
<th>San Andreas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>SD</td>
<td>SD</td>
<td>SD</td>
<td>DN</td>
</tr>
<tr>
<td><strong>Peak Harvest</strong></td>
<td>April 29--May 13</td>
<td>April 22--May 13</td>
<td>April 15--May 2</td>
<td>April 25--May 6</td>
</tr>
<tr>
<td><strong>Yield (lb)/plant</strong></td>
<td>1.8</td>
<td>1.7</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Berry wt (Oz)</strong></td>
<td>0.7</td>
<td>0.5</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Yield (lb)/Ac</strong></td>
<td>31,320</td>
<td>30,415</td>
<td>23,518</td>
<td>24,881</td>
</tr>
<tr>
<td><strong>% Mark. yield</strong></td>
<td>51.2</td>
<td>47.3</td>
<td>58.6</td>
<td>40.4</td>
</tr>
</tbody>
</table>

Assuming a 1 x 5 foot row spacing (about 17,400 plants per acre) and the per plant yields listed in the above table.
Comments: Camarosa

Early berries were often frog-legged or deformed due to cold induced pollination problems.

But very few flowers were lost to cold.

And plants themselves grew quickly with no cold damage to leaves.
Comments: Camarosa

- Low disease susceptibility
- First cultivar to show signs of downey/powdery mildew but once treated plants recovered with no re-infestations. Very minor problems with gray mold.
- Minor mite damage but with spray and predatory mites populations were controlled.
- Also minor cricket damage.

http://www.bordeaux.inra.fr/eu strawberrydb/accession/114
Comments: Chandler

- Appeared moderately cold tolerant
- Minor splitting of the berry skin was recorded, with some flower loss
- Moderate disease susceptibility
- Reduction in fruit quality was due to very soft berries, and heavy gray mold occurrence
- Minor to no powdery/downey mildew observed
Comments: Chandler

• Moderate mite damage
Comments: St. Festival

• Very minor frog-legging
• Early berries were soft, mushy, with splits in the skin
• All believed to be caused by freezing and thawing of the fruit tissue?
• Cold induced pollination problems also observed
Comments: St. Festival

- Low disease susceptibility
- Very minor powder/downey mildew observed on leaves
- Minor gray mold
- Only cultivar to develop a white slime-looking mold on some berries
- First to get aphids and mites
- Heavy yield losses occurred due to a mite infestation
- Highest marketable yield (58.9%)
Comments: San Andreas

• Cold induced pollination problems, with some minor splitting of the fruit skin
• Moderate to high susceptibility to disease
• Abnormal berry color and seed formation was identified as symptoms of powdery mildew
• Moderate susceptibility to gray mold
Comments: San Andreas

• Minor mite damage but with spray and predatory mites populations were controlled
• Also minor cricket damage
• Lowest marketable yield (40.6%)
Low Tunnels- New Research
Resources

Interactive Sustainable Strawberry Budget
http://strawberry.uark.edu/519.htm#Garcia
Budget Tool (.xlsm document)
User Guide for budget tool (PDF)

Project: A series of videos on strawberry production for beginners
YouTube: https://www.youtube.com/user/revitalizingstrawber
National Strawberry Sustainability Initiative: Moving the Needle
strawberry.uark.edu

Organic Strawberry Production Guide-Cornell
Summary

"Doubtless God could have made a better berry, but doubtless God never did."
17th century English writer Dr. William Butler
Questions?

“This is a project funded by a grant from the Walmart Foundation and administered by the University of Arkansas System Division of Agriculture Center for Agricultural and Rural Sustainability.”