Organic Berry Production and Use of Tunnels

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Outline

• Why Organic Berries?
• Opportunities for Tunnel Production
• Challenges in Tunnel Production
• Our Experiences with Berry Production
• Tunnel Modifications
• Summary and Conclusion
Why Grow Organic Berries?
Why Organic?

- Capture high value market
- Minimize environmental impacts

Capitalists with a conscience
Organic Berry Opportunities

• Blackberries
• Blueberries
• Raspberries
• Strawberries
• Grapes
Why Organic Berries?

- Few disease pests
- Few insect pests (until recently)
- Few registered pesticides
- Capitalize on higher value for a high value crop
Why Grow in Tunnels?

Because!
Why Tunnels?

Environmental Modification with
A. Temperature Modification
B. Precipitation and Moisture Modification
C. Light modification
D. Wind reduction

Thereby allowing the grower to
1. Extend the growing season
   • Advance the Spring Season
   • Extend the Autumn Season
2. Minimize impacts of weather (hail, wind, etc.)
3. Mitigate Pest Problems
4. Capture Organic Market Opportunities; high value
The Opportunities and Benefits from Tunnels

- Reduced Risk of High Risk Crops
- Never a “lost day” due to rain
  - You will always have crop to sell
- Increase Value of Crops
  - Increased yields; size, total yield
  - Out-of-season production
  - Reduced costs
- Extended Season means Extended Cash-Flow for the farm
- Potential Reduced use of Pesticides
- Opportunity for Sustainable and Organically Produced
- Possible better Economics
Opportunities for Specialty Crops

• Applications for High-Risk, High Value Fruit Crops

• Multi-Scale
  Suited to Multiple Markets
  – On-farm sales
    • Agritourism/Agri-entertainment
  – Farmers’ Markets
  – Local Retail
  – Wholesale
Tunnels are Not without Problems

• Management of the tunnels
  – Daily operation

• Problems with tunnel temperature management
  – Opening and closing the tunnels
  – Over-heating
  – “Super-cooling”
    • Problem of increased frost risk

• Problems with irrigating during the winter

• Soil management

• Insect pests; different pests, rapid population growth

• Pollination

• Problems with markets being open

• Problems with investment costs and return on the investment
A Place for Tunnels

Tunnels have a place in the production system to *compliment* field production.
Potential For Fruit in Tunnels

**Easier**
- Strawberries
- Blackberries
- Blueberries
- Raspberries

**More Difficult**
- Grapes
- Apples
- Peaches and Cherries
Other Potential Opportunities

• Peaches and Nectarines
• Cherries and Plums
• Figs
• Kiwi
• Growing Organically
• Movable Tunnels with other crops
Our Experiences

• Blackberries
• Raspberries
• Blueberries
• Strawberries
Berry Production in Tunnels
Berry Problematic

- Berry production season is short: 4-6 weeks
- Rain can reduce summer floricane cropping harvest
- High temperatures limit raspberry production in South
- High late summer temperatures limit flower formation and fruit set of primocane fruiting blackberry and raspberry cultivars
- Early fall freezes (20-Oct) limit fruiting of primocane cultivars
Berry Crops for Tunnels

**Spring Crop**
- Floricane producing Blackberries
- Floricane producing Raspberries
- Blueberries
- Strawberries

**Fall Crop**
- Primocane Producing Blackberries
- Primocane Producing Raspberries
Our Projects

Sustainable/Organic Berry Production in Tunnels

A. 2006-2010

1. Advancing Spring Production
   - Blackberries: Navajo, Ouachita, Arapaho
   - Raspberries: Dormanred, Prelude, and Encore

2. Extending Fall Production
   - Blackberries: Prime-Jan, Prime-Jim, APF46
   - Raspberries: Dinkum, Caroline, Autumn Bliss

3. Double-Cropping Primocane Cultivars

B. 2012-2015 Studies

1. Advancing Spring Production
   - Blueberries: Earliblue
   - Blackberries: Natchez

2. Extending Fall Production
   - Primocane Raspberries: Nantahala, Josephine, Autumn Bliss
   - Primocane Blackberries: PrimeArk 45®, PrimeArk Freedom®, APF###
Tunnels may extend the summer harvest season from 4-6 weeks during summer to 12-20 weeks during the year.
Observations from First Trials

- In both Spring and Fall Trials - Tunnels provided significant yield savings in rainy spring seasons
- Spring Harvest was advanced approximately 10-14 days. Potential for more with tunnel-in-tunnels and/or heat addition
- Across 3 seasons, HT spring blackberries were 30% larger and had >200% greater yields
  - Navaho performed the best although did not shift the season much before earlier ripening field produced cultivars
- Across 3 seasons HT spring raspberries yielded >400% more than field produced
  - Dormanred and Prelude had greatest yields
- Extended fall production until December in 2 of 3 years
- Annual and total Autumn Harvest primocane blackberry yields only 40% of spring floricane yields, but raspberry primocane and floricane yields almost equal
- Across 3 seasons, HT yields were ~150% greater than the field
  - Prime-Jan, although producing larger fruit in tunnels did not have any greater yield of HT vs Field; other cultivars (Prime-Jim and APF 46 had larger yields)
HT vs Field Yield Comparisons

**Floricane Berries**

- **Tunnel**: FL-Black (7500 g, 3 seasons 2007-2009), FL-Rasp (2500 g, 3 seasons 2007-2009)
- **Field**: FL-Black (3000 g, 3 seasons 2007-2009), FL-Rasp (1000 g, 3 seasons 2007-2009)

**Primocane Berries**

- **Tunnel**: PR-Black (3000 g, 3 seasons 2007-2009), PR-Rasp (2000 g, 3 seasons 2007-2009)
- **Field**: PR-Black (1000 g, 3 seasons 2007-2009), PR-Rasp (500 g, 3 seasons 2007-2009)
Cumulative Yield (Lbs / acre)

Production System

Field

High Tunnel

39% Increase

NOTE: Pollination Problem

CV: Natchez
Field vs Tunnel Cumulative Yield

2014 Natchez Blackberry Cumulative Yield

Cumulative Yield (grams)

Date

Date of 50% of Harvest
Last HT harvest 7/11

FD  HT

*Error bars represent standard error from the mean.

CV: Natchez
Field vs Tunnel Yield PrimeArk 45

High HT temps due to insect screen

*lbs/A calculated at 8 ft row spacing

*Error bars represent standard error from the mean.

CV: PrimeArk45
Cumulative Yield (Lbs / acre)

<table>
<thead>
<tr>
<th>Year</th>
<th>Field</th>
<th>High Tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

106% Increase

Production System

CV: PrimeArk45
Field vs Tunnel Cumulative Yield

CV: PrimeArk45   2014

*Error bars represent standard error from the mean.
Field vs Tunnel Raspberry Yield

*Error bars represent standard error from the mean.*

2013
Field vs Tunnel Raspberry Yield

2013

Average Yield (lbs/acre)

37% Increase

*lbs/A calculated at 8 ft row spacing
Success and Challenges

• Advanced Crop, but not as much as planned
• Difficulty delaying flowering and fruiting of Primocanies to capture season extension
• Pests: Mites, aphids, white flies
• Temperature Problems: excessive heat, frosts
• Pollination
• Only need the tunnels for 3-5 months/year
Observations and Thoughts

• Tunnels can **allow raspberry production** in our region more readily
• Spring production of blackberries, raspberries, and blueberries **advanced 2-4 weeks**
  – **Must select earliest maturing cultivars** to make it work most effectively
• **Not all cultivars perform well** in tunnels.
• Potential for berries; not completely developed methods
• Tunnels may provide significant **opportunity for organic production**
  – **May be more sustainable with reduced pesticides and water conservation**
Observations and Thoughts

• Tunnel Size matters
  – The bigger the tunnel, the more environmental modification
  – The bigger the crop, the bigger the tunnel
Organic Considerations
Competitive Vegetation Management

• Used combination of
  – Plant row border tillage
  – Plant row border weed barrier
  – Wood Chips
  – Mechanical/Hand removal

• Competitive vegetation was less of a problem in tunnels and easier to manage
Disease Management

• Select cvs with resistance or minimal problems
• Minimal Disease Problems
• Preventative Lime-sulfur
• Sanitation
Insect Management

Insects were challenging

- Blackberries
  - Broadmites
    - Became a problem in the tunnels (primarily)
    - Controlled by application of light oils and M-Pede
  - Aphids
    - Not good control by lady beetles
      - Protected by ants
    - Predatory spotted lady beetle (*Coleomegilla maculata*)
      was effective
    - Parasitic wasp (*Aphidis coemani*)
    - Soap products were ineffective
    - Pyganic moderately effective
    - Aza-direct some effect
Insect Management

Insects were challenging

- Blackberries and Raspberries
  - Spider Mites;
    - 2-spotted, McDaniel, Carmine
    - Severe problem in tunnels
    - Very difficult to control
    - Some control with predator mites
      - *Neoseiulus fallacis, N. californicus*
      - Need to be applied very early upon detection
  - Some control with soap
Insect Management

Insects were challenging

• Blackberries – tunnels only
  – Flea beetles; shot-holing
    • Became a problem in tunnel
    • Controlled with Neem, Aza-Direct
  – Stink bugs
    • Controlled with Pyganic
  – White Flies
    • Controlled with light oil, Pyganic, Aza-Direct
Insect Management

Insects were challenging

• Blackberries
  – Redneck cane borers
    • More problem in field than tunnel
    • Practice good sanitation
    • If adults present,
      – Light oil (JMS Stylet), Pyganic, Botanigard
Insect Management

Insects were challenging

• All Berries
  – Spotted wing drosophilila
  – Marginal control in the field
    • Pyganic, Neem, Aza-Direct
  – Better control in tunnel
    • Exclusion, trapping, Pyganic
Nutrition Management

• Monitor nutrition with foliar analysis following standard protocols
• Monitor soil pH and OM annually with soil test
• Apply organic nutrient source as prescribed on N basis
• Notes for Blueberries
  – Use of compost and organic nutrient sources can raise pH
  – May need to adjust with soil or fertigation applied sulfur
Tunnel Modifications
Tunnel Problems and Solutions

Problems

• Tunnels only provided 2 wks advance bloom; goal was 3-4
• Tunnels provide minimal frost protection

Solutions

• Tunnels in Tunnels
• Supplemental Heat
Tunnel Temperatures

- Tunnel
- Tunnel with Heat Conservation/Addition
- Field

Sunrise - Mid-Day - Sunset - Sunrise
Tunnels in Tunnels
Tunnels in Tunnels & Row Covers with Supplemental Heat
Methanol chafing dish burners
Approx 1/100sqft
Burn 6-7 hrs
Tunnel-in-Tunnels
Do Tunnels Advance Bloom?

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Date of Full Bloom</th>
<th>Days Advance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>Field</td>
<td>1-May</td>
<td>6-May</td>
</tr>
<tr>
<td>High Tunnel</td>
<td>18-April</td>
<td>14-April</td>
</tr>
<tr>
<td>HT+ Tunnel in Tunnel</td>
<td>12-April</td>
<td>8-April</td>
</tr>
</tbody>
</table>

CV: Natchez
Do Tunnels Continue Harvest?

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Date of Last Significant Harvest</th>
<th>Days Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
<td>15-Nov 1-Nov 8-Nov</td>
<td>0</td>
</tr>
<tr>
<td>High Tunnel</td>
<td>15-Nov 12-Nov 13-Nov</td>
<td>5</td>
</tr>
<tr>
<td>HT+ Tunnel in Tunnel</td>
<td>27-Nov 14-Nov 21-Nov</td>
<td>13</td>
</tr>
</tbody>
</table>

CV: PrimeArk 45
TNT Summary and Conclusions

• Tunnels provide increased daily heat accumulation; advanced bloom, extended harvest
• Tunnels provide minimal heat conservation during a frost
• Tunnels with supplemental heat had some temperature increase; heat added 0-5ºF
• TnT provide increased daily heat accumulation over tunnels further advancing bloom and extending the season
• TnT provide increased heat conservation during a frost; added 2-5ºF above tunnels
• TnT with supplemental heat had significant temperature increase; added 5-10ºF
• TnT can limit pollination
Tunnel Problems and Solutions

Problems

• Spotted wing drosophila in organic production

Solutions

• Screening

80 g/m² mesh
2015 Screened High Tunnel

Changed from 25 g to 80 g/m² mesh insect screen on lower sides and ends and misting overhead
Screened Tunnels

• Screened tunnels in combination with lure traps and sticky cards reduced SWD by >95%
• Screened tunnels had significantly increased temperatures
• Screened tunnels had significantly increased mite problems
Tunnel Problems and Solutions

Problems

• Increased heat in screened tunnels
• Early bloom of primocane blackberries

Solutions

• Shading
• Microsprinkler cooling
**Effect of Shade in HT on ‘Prime-Ark 45’ Blackberry Yield**

*Error bars represent standard error from the mean (N=3). Calculations per hectare based on 2.4 meter between row spacing.*
HT Shade Study Summary and Conclusions for Blackberry

- Shading ~1 month before fruiting showed no significant effect on reducing air temperature during flowering; may have reduced tissue temps (not analyzed)
- After 2 years studies, shading had minimal to no effect on time of flowering and crop maturation.
- Shade significantly reduced flowering and fruiting; not a pollination effect
  - Reduced flower number not set
  - May have delayed flowering beyond the study period
- Shade significantly decreased cumulative yield of primocane blackberries on average 30-40% over two growing seasons
- Shade increased berry weight in blackberry but could be attributed to lower yields
- Shade significantly increased marketable yield percentage in one growing season but not enough to justify cost and labor of shading
- Shade had no effect on soluble solids content
Effects of Shade on Primocane Raspberry Yield

Cumulative Yield (g)

Date

2013

7/5  7/25  8/14  9/3  9/23  10/13  11/2  11/22  12/12

*Error bars represent standard error from the mean (N=3). Calculations per hectare based on 2.4 meter between row spacing.

Cv: Nantahala
HT Shade Study Summary for Raspberry

- Shading ~1 month prior to expected yields significantly increased yield in ‘Nantahala’ raspberry by ~30% for one growing season.
- Additional seasons of data needed to conclude effect on yield.
- Shade reduced berry size and marketable yield percentage.
- Shade did not have any effect on soluble solids content of raspberry.
- Reducing the amount of shade may have potential to reduce fruit quality effects.
HT Evaporative Cooling with Microsprinklers

Materials and Methods

Treatments:

Exp 1: Micro-Misting - 2014
- HT Continuous Misting
- HT 1-hr Misting
- HT No Misting
- Ambient/Field

Exp 2: Fogging - 2015
- Water cooling/mist treatments were implemented when HT temps reached ~88°F
Effect of high tunnel insect screening on **hourly average ambient temperature difference** during mid-late August, 2014.

![Graph showing temperature difference over time between screened HT and ambient conditions. Error bars represent standard error from the mean (n=4).](image)

*Error bars represent standard error from the mean (n=4).*
Effect of misting/cooling on **hourly average temperature** of a screened HT during mid-late August, 2014.

*Error bars represent standard error from the mean (n=4).*
Treatment comparison of **hourly average maximum temperature** to HT No Mist in a screened HT during mid-late August, 2014.

*Error bars represent standard error from the mean (n=3).*
Treatment comparison of **hourly average maximum temperature** to HT No Mist in a screened HT during mid-late August, 2014.

*Error bars represent standard error from the mean (n=4).*
Summary and Conclusions

- Evaporative cooling has potential to cool tunnels
- Micro-sprinklers were not sufficient, but had an effect
- Single hour sprinkling in the morning was insufficient

Current Work - 2015
- Foggers decreased tunnel temps 10-15F from HT temps, 3-5F below ambient
- Did not wet foliage
- Significantly increased HT humidity; possible problems
- Pulsing may reduce water use and humidity
Making Tunnels Work
Making Spring Tunnel Production Work

- Select the right cultivars for the purpose
- Select cultivars with high disease Rs
  - Examples:
    - For spring blackberries and blueberries, select earliest bearing
      - Examples
        - Blackberries: Natchez, Arapaho
        - Raspberries: Prelude, Autumn Bliss, Caroline
          (possibly Blueberries: Earliblue, Bluetta)
    » Strawberries – cultivars with proven local track record

- Select cultivars for field production that span the season; early to late
Making Spring Tunnel Production Work

• Close the tunnels in mid-Winter
  – Mid-January to Early February
• Cover plants with a row cover “blanket” or TnT to conserve heat
• Add Supplemental Heat when temperatures are below 35°F
Tunnel Temperature Mgmt

• During Day: may be $50^\circ F$ above outside temps

• During Night: As cold or sometimes colder
  – Tunnels only have $0-2^\circ F$ temperature nighttime temp conservation
    • They may “super-cool” going below outside temp
  – Needs additional management
Frost Protection

• So, you moved bloom from naturally after the last frost, until before the last frost
  YOU NEED FROST PROTECTION
• Tighten the House
• Increase soil Moisture
• Employ Row-Covers, Frost Curtains, or TnT
• Add supplemental heat starting at about 34°-36°F
Additional Thoughts on Tunnel Temps

• Tunnels-in-Tunnels and row covers are important for out-of-season production
• Heat conservation and retention are important; heat sinks
• Soil Moisture
• Black, landscape fabric mulch floor
• Inflated bi-layer poly roof
• Roof Blankets
• Supplemental Heat
  – Gas, biomass furnaces
Making Tunnels work for Extended Autumn Production

- Select *latest* blooming and ripening cultivars
- Delay flowering and fruiting with cultural means (e.g. pruning, shade have not been effective)
- Start closing tunnels when temps (day or night) go below 50°F
- Need pollinating insects
- Have frost protection strategy ready
- Flowering to ripening period extends
  - Last bloom likely in mid-October early November
Pollination

*Need to Provide Pollinating Insects*

- All of the berries require insect pollination
- Tunnels may bloom before or at cooler temperatures than “outside” pollinating insects are working
Harvests and Quality

• Increased total yield in tunnels (30-200%)
  – Due to more harvests, larger fruit
• Marketable yield (% for fresh use) is improved in tunnels
  – Fewer sunburns
  – Fewer “rain rots”; water-ruined fruit
  – May see more “heat stressed” fruit
• Requires more harvests and more frequent harvest
Additional Thoughts

• Water management in tunnels must be watched closely
• Temperature Management is critical
• Have experienced better summer survival in tunnels
  – Temperature?
  – Light?
  – Weeds?
Observations from Other Places

- Tunnels can significantly change production system for local/regional food supplies
- Tunnels tend to be 10ft or less in height
- Tunnels have roof and end vents
- Tunnels are screened
- Many tunnels are “recessed” into the ground for thermal protection
- Half-Tunnels with north walls
Summary

• There is potential and opportunities for High Tunnel Fruit Production, especially for local markets
  – Blackberries, raspberries, blueberries, strawberries, grapes.
  – Other crops: Peaches, Plums, Cherries, figs, kiwi (??)

• High Tunnels Excellent Potential for Season Extension; Good Potential for Organic Production

• Tunnels fit as a part of a farm management and profitability plan to compliment field operations

• Technology and management of tunnel fruit production is being developed and proving good for our region
A Place for Tunnels

Tunnels have a place in the production system to *compliment* field production.
Questions?

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