



Missouri State University  
Darr School of Agriculture STATE FRUIT EXPERIMENT STATION

## Overview of High Tunnel Fruit Production

Greenhouse and High Tunnel Workshop  
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Country	Area (ha) <sup>a</sup>	Crops (in order of importance)
China	360,000	Cucumber, tomato, sweet pepper
Spain	55,000	Melons, tomatoes, sweet pepper
Japan	52,571	Tomato, melons, strawberry 🍓
Italy	26,000	Tomato, summer squash, sweet pepper
Korea	21,061	Cucumber, chinese cabbage, tomato
Western North Africa	11,400	Tomato, sweet pepper, cucumber
Turkey	10,800	Tomato, cucumber, melon
Netherlands	10,800	Tomato, sweet pepper, cucumber
France	9,100	Tomato, cucumber, strawberry 🍓
United States	5,000	Tomato, cucumber, lettuce
Greece	4,620	Tomato, cucumber, eggplant
Middle East	4,300	Tomato, cucumber, sweet pepper
Germany	3,300	Tomato, cucumber, lettuce
Belgium	2,250	Tomato, lettuce, herbs, cucumber
Arabic peninsula	1,930	Cucumber, tomato
Eastern North Africa	1,700	Cucumber, sweet pepper, tomato
United Kingdom	1,600	Tomato, cucumber, lettuce
Canada	1,470	Tomato, cucumber, sweet pepper

Source: Overview of the Use of High Tunnels Worldwide. Lamont. HortTechnology.

Estimated area (ha) of protected crops (plastic greenhouse and high tunnels) by region worldwide.

Region	Area (ha) <sup>a</sup>
Asia	440,000
Mediterranean	97,000
Africa + Middle East <sup>b</sup>	17,000
Europe <sup>c</sup>	16,700
Americas	15,600
Total	586,300

<sup>a</sup>1 ha = 2.4711 acres.  
<sup>b</sup>Excludes European countries on the Mediterranean Sea.  
<sup>c</sup>Source: Overview of the Use of High Tunnels Worldwide. Lamont. HortTechnology.


### High Tunnel Fruit Production in the US

- Small fruits – Kathleen Demchak “Small Fruit Production in High Tunnels”
  - In the US and Canada, growers are using high tunnels for raspberry, blackberry, strawberry and blueberry production.
  - Greatest acreage in California (4,000 acres) on plants covered when they are producing fruit.
  - Oregon – 100 acres of blackberry and blueberry
  - About 10 acres of raspberries in British Columbia and 14 in Ontario, mostly primocane bearers.
  - West coast uses multi-bay tunnels.
  - Less production in the East in single bay tunnels.
- Tree fruits – “The Final Frontier” Gregory A. Lang, Michigan State

### Large and small scale production

**Multi Bay Tunnels**


- Global/West Coast Large Scale
- Three seasons in cold areas
- Lower cost per square foot
- Greater risk of wind damage to tunnel




Source: Haygrove

**Single Bay or Stand Alone Tunnels**

- Eastern US Small Scale
- Greater season extension
- Higher cost per square foot (but lower acreage under tunnel)
- Spring freeze protection
- Winter protection
- Can be moveable on tracks



<http://ncdc.unl.edu/high-tunnel-workshops-webinars>



**Haygrove Growing**

The Company was founded as Haygrove Fruit in 1989 by Wayne Dennis, following a University research project that identified growing strawberries in polytunnels. Rapid expansion into 4 commercial berry quality followed (and is still ongoing).



**Strawberries**

- Driscoll® Pasadena™
- Driscoll® Amesti™
- Driscoll® Magdalena
- Camarillo
- Driscoll® Lusa™
- Driscoll El Dorado
- Driscoll Jubilee

**Raspberries**

- Driscoll® Maravilla
- Driscoll® Cardinal
- Driscoll® Sevillana
- Driscoll® Ambrosia™
- Driscoll® Carmina™

**Blackberries**


- Driscoll® Carmel
- Driscoll® Eureka
- Driscoll® Cowles
- Driscoll® King George™

Midwest/Upper South/Northeastern US – season extension, local markets, diverse crops




Reasons to use high tunnels in production

- High tunnels are used for different reasons in different places.
- Rain exclusion
- Wind modification
- Temperature regulation
- Sun protection
- Extend the season
- Target production for specific time
- Reducing pressure of some pests (although some pests may be more of a problem in tunnels – mites, powdery mildew)



Challenges to high tunnel fruit production


- Fruit crops are perennial!!
- Higher cost for tunnel
- Learning curve
- Risk of tunnel damage from weather (high winds, hail)
- Nutrient management
- Water management
- Pollination management
- Different pest complexes



Multi-bay tunnels damaged in thunderstorm in August, 2004. Photo credit: Ted Carey, Kansas State University.

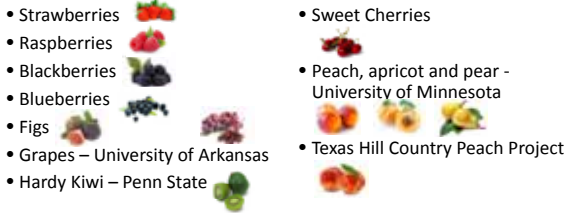
Why grow fruit crops in high tunnels?

- Great worldwide demand for fruits and berries due to health reasons – antioxidants
- Extending the production season
- Protecting crop from the elements
- Reducing pest/disease pressure
- Increase in profitability
  - Higher yield
  - More marketable fruit
  - Larger fruit size
  - Target periods of high demand in season



What fruit crops are grown in high tunnels?

<p><b>Small Fruit Crops</b></p> <ul style="list-style-type: none"> <li>• Strawberries</li> <li>• Raspberries</li> <li>• Blackberries</li> <li>• Blueberries</li> <li>• Figs</li> <li>• Grapes – University of Arkansas</li> <li>• Hardy Kiwi – Penn State</li> </ul>	<p><b>Tree Fruit Crops</b></p> <ul style="list-style-type: none"> <li>• Sweet Cherries</li> <li>• Peach, apricot and pear - University of Minnesota</li> <li>• Texas Hill Country Peach Project</li> </ul>
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**In-ground or containers/substrait?**

**Field grown strawberries**

- Matted row - manage for 3 years
- Plasticulture – annual system
  - Plant in fall, harvest next spring with Junebearers
- Harvest period
  - Short Day (Junebearing) – May to June
  - High tunnel plasticulture – April harvest 7 – 8 months after fall planting
  - Day neutral – May – September (peak in late part of the year) – Cornell Plasticulture research.
  - Day neutral production limited by summer heat.

Photo source: Simpson's Family Farm

**Challenges to field production of strawberries**

- Spring freeze injury
- Rain and botrytis during harvest
- Winter cold injury
- Weeds/soil disease/fumigation

Photo source: NC Strawberry

Photo source: Simpson's Family Farm

**Strawberry production in high tunnels**

- ANNUAL SYSTEM – herbaceous perennial fits into annual rotation with vegetable crops.
  - Strawberries can be followed by tomatoes, peppers, melons, cucumbers or squash.
- More reliable production
- Better fruit quality, less rot
- Earlier production
- Extended production
- Protection from spring freezes
  - Earlier flowering
- Protection from winter cold

(Texas A&M AgriLife Extension Service photo by Russ Wallace)

**Low tunnel production**

- Northeast: Dr. Marvin Pritts of Cornell University said it is about four times cheaper on a per area basis to grow strawberries in a low tunnel than in a high tunnel.

Source: Utah State University

<http://hortamericas.com/blog/high-tunnels-enable-growers-to-increase/>


**Substrait production – single or multi levels**

- Intensive production
- Exacting fertigation and moisture level management
- Large scale production
- Penn State – water management issues of day-neutral strawberries in gutters

Haygrove <http://www.haygrove.co.za/substrate-growing/products/>

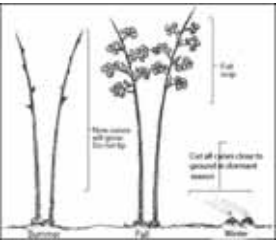
### Raspberries – red and black

**Florican production**



Canes do not bear fruit in the first season. The canes overwinter and produce fruit in the second season and then die. Fluctuating winter temperatures in Missouri may injure overwintering raspberry canes.


**Primocane production**



No overwintering canes, no problem with winter injury.

### Challenges to field production of raspberries in Missouri

- Not a viable commercial crop in Missouri
- Most cultivars bear in August when heat is an issue
- Sunburn
- Diseases due to high humidity and rainfall
- Sensitive to heavy soils and wet soils
- Late bearing cultivars harvest period cut short by frost
- Floricanes may be injured by cold in fluctuating winter temperatures



Source: Thaddeus McCamant, Central Lakes College

### Raspberry production in high tunnels



- More reliable production
- Higher yields
- Larger berries
- Better quality – less disease
- Improved shelf life
- Extended growing season
- Protection from frost
- Protection from heat (shade cloth)
- Pollination?
- Longer in-ground life of planting
- May remove plastic in winter
- Early tipping to regulate time of harvest is an area of active research.

### Challenges to growing blackberries in the field

- Winter injury to canes
- Rain suspending harvest
- Disease and pests
- New rotating arm trellis may revolutionize field production by offering winter protection and more efficient harvesting.



### High tunnel blackberry production

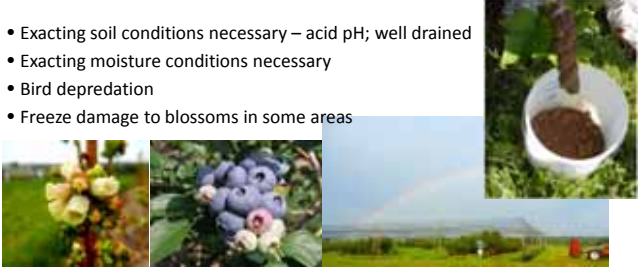
- Mostly in west coast
- Not as common as raspberries and strawberries in the east.
- Early tipping to manipulate harvest is an area of active research





Project investigator Curt Rom looking at raspberries and blackberries in high tunnels at the University of Arkansas. Photo credit: Russel Cothren/University of Arkansas

### Challenges to field blueberry production

- Exacting soil conditions necessary – acid pH; well drained
- Exacting moisture conditions necessary
- Bird depredation
- Freeze damage to blossoms in some areas



**High tunnel blueberry production**





- Trials on Southern Highbush cultivars in Florida and Georgia.
- Earlier production
- Higher production
- Ready protection from birds (netting on side walls)
- Possibly saving water in frost protection in frost prone areas
- Bumblebees
- Substrait production at Haygrove.

University of Florida <https://news.ifas.ufl.edu/2012/11/tunnel-technology-could-help-florida-blueberry-growers-ufifas-study-suggests/>

**Major problem worldwide - SWD damages ripe fruit**



**SWD Management**

- Spray weekly at night for raspberries in high tunnel due to pollinators.
- Other berries can be sprayed during the day
- Test berries for larvae (1c salt/gallon water) weekly – sugar solution may also be used

**A Fixed-Spray System for SWD Management in High Tunnel Raspberries**  
 Arthur Agnello, Andrew Landers, and Greg Loeb  
 Department of Enomology, NYSAES, Cornell University, Geneva NY




<http://www.hort.cornell.edu/grower/nybga/swd/pdfs/Management-SprayTechnology/Fixed%20Sprayline%20NY%20Fruit%20Quarterly.pdf>

**Challenges to field table (wine) grape production**



- Fruit cracking after rain just before harvest
- Bird depredation
- Fungal diseases
- Japanese Beetles (2016 in Missouri – extremely severe). Japanese beetles not as severe in high tunnels.
- Three years to harvest fruit.
- Some cultivars susceptible to winter injury.

**High tunnel grape production**




- Trellis must be installed before tunnel
- Earlier production in season
- Earlier trellis fill?
- No fruit cracking
- Higher yield
- Less disease
- Protection from birds (if sides are netted)

Source: Project Report – Evaluation of Cultivars and Trellis Systems for Advanced Season and Low Pesticide Input Table Grape Production under High Tunnels for the Southeast U.S. Garcia and Johnson, University of Arkansas


**Challenges to field grown sweet cherry production**

- Grown in drier areas of the West Coast
- Grown in more humid east Michigan, New York
- Diseases
- Insects (Japanese beetle)
- Fruit cracking due to rain during harvest



Source: EurekAlert!, the online, global news service operated by AAAS, the science society. [www.eurekalert.org](http://www.eurekalert.org)

**High tunnel cherry production**



- Dwarfing, precocious rootstocks – Gisela series
- No cracking from rain
- Less disease
- Larger fruit size (not necessarily larger yield)
- Less insect pressure

Sweet cherry trees in a high tunnel. The yellow-capped boxes in the background are bumblebee colonies for pollination purposes. Photo: Greg Lang, Michigan State University

**Any Questions?**