Hoop Houses and Tunnels

Wednesday morning 9:00 am

Where: Ballroom D

MI Recertification credits: 1 (COMM CORE, PRIV CORE)
CCA Credits: CM(2.0)

Moderator: Adam Montri, Horticulture Dept., MSU

9:00 am	Tips for Tunnels of All Types
	• Vernon Grubinger, Vegetable and Berry Specialist, Univ. of Vermont
9:55 am	Summary of MSU High Tunnel Economic Study
10:15 am	Cherry Tomato Production in High Tunnels
	• Trent Thompson, Green Gardens Farm, Battle Creek, MI
11:00 am	Session Ends

Tunnels of All Types

Vern Grubinger
Vegetable and Berry Specialist, University of Vermont Extension

Since the dawn of horticulture, growers have found ways to extend the length of time that their crops could be produced. Thousands of years ago, this was done by selecting protected production sites with favorable microclimates. Hundreds of years ago, cold frames and hot beds with bottom heat from decomposing manure were used. Then came glass greenhouses. Over the past few decades, there's been an explosion of season-extension options for growers to choose from, most of which rely on 'plastic' in one form or another, from mulches and row covers to plastic-covered greenhouses. Most of the season-extension structures that fall between 'ground-level covers' and 'permanent greenhouses' can be referred to as 'tunnels.'

Tunnels vary widely in size, shape and purpose. Unlike mulches or floating row covers, tunnels have some type of rigid support for the plastic cover. And unlike greenhouses, tunnels are not equipped with poured foundations and/or elaborate heating and cooling systems. Typically, tunnels rely on solar energy for heat and passive ventilation, while greenhouses usually have a furnace and may have mechanical as well as passive ventilation. However, there isn't a bright line between where tunnels end and greenhouses begin.

There are several distinct types of tunnels that can be differentiated using the terms high tunnel, hoophouse, caterpillar and low tunnel. This terminology is not always consistent, in part because characteristics may be 'mixed and matched' across the types. For example, while hoophouses are usually unheated, there are plenty of exceptions to that, especially in northern locations. So, take these definitions with a grain of salt, they are useful only if they help you understand the different kinds of options that are available for growing crops under cover.

High tunnels and hoophouses are very similar (some might say the same) as they generally have steel pipe frames set into the ground, are covered with greenhouse grade plastic, and employ roll-up sides for passive ventilation. They may be Quonset shaped ('half circle' frame) or Gothic shaped (peaked frame). Gothic frames are better suited to shedding snow, and they usually come with more internal bracing so they make sense where severe winter weather is a concern. Whatever their shape, a strong frame and secure anchoring help structures stay in place during high winds.

Hoophouses and high tunnels both tend to employ drip irrigation, though sometimes hand-watering or micro-sprinklers are used. The greenhouse film used to cover hoophouses and high tunnels may be single layer or double-layer with an inflation fan. Hoophouses are generally unheated, while high tunnels can go either way.
When they are heated, high tunnels usually have 'supplemental' heat rather than the large furnaces typical of greenhouses. Some heat may be needed in cold climates if tunnels are used for warm-season crops like tomatoes rather than cold-hardy crops like leafy greens. High tunnels are also more likely than hoophouses to have HAF (horizontal air flow) fans for mixing the internal air.

Hoophouses tend to be smaller in height and width than high tunnels, with a simple frame of hoops (bows) plus a central purl in (perhaps several) running the length of the tunnel to add structural strength and rigidity. Very small hoophouses may rely only on endwall openings for ventilation. Roughly speaking, a hoophouse may be 12 to 17 feet wide and 8 to 12 feet tall at the ridgeline.

High tunnels are typically Gothic shaped, 17 to 40 feet wide and 12 to 20 feet high. The length of these structures varies from about 24 feet to several hundred feet, though 48 feet and 96 feet are common lengths. They typically have multiple purlins as well as cross-braces for added structural stability. Some high tunnels have a ridge vent at the top of the frame to optimize passive ventilation; others have gable ends with large openings such as garage doors, peak vents or other openings to enhance access and ventilation.

Multibay structures are hoophouses or high tunnels constructed side-by-side with 'gutters' at the roof seams between each bay. Typically, multibay hoophouses such as Haygroves are covered only during the growing season, and the cover is rolled up or removed during the winter so that snow load and wind are not an issue. Multi-bay high tunnels that remain covered all year must have enough structural strength to bear the anticipated worst-case snow load, and adequate gutters between the bays to capture and remove rain and melting snow. The structures may need to be heated to melt snow or ice if it accumulates.

Caterpillars and low tunnels differ from hoophouses and high tunnels in that they are put up for only part of the year, and then taken down. They have frames that are much less durable, and they much more portable.

Caterpillars, sometimes called walk-in tunnels, are narrow single bay structures, often barely tall enough to stand up in. They have a segmented appearance, thus the caterpillar moniker. They are less expensive than hoophouses and high tunnels, costing about a quarter of the price per unit of area covered. They provide less cold temperature protection than high tunnels and hoophouses but more than low tunnels. The width of caterpillars ranges from about 8 to 18 feet wide and the length may be up to several hundred feet, depending on the beds they are intended to cover and the size of available covers.

Caterpillars can be covered with greenhouse film, spun bonded row cover, shade cloth or other materials suitable for the crops being grown. The supports, or bows, can be made from PVC pipe, electrical conduit, or steel pipe. These are placed over ground stakes made of rebar or steel pipe, or set into the ground about a foot deep. Bows are spaced six to ten feet apart, depending on the expected wind exposure. A heavy duty (1/4 inch) rope is tied from bow to bow to form a peak purlin; this rope must be attached to heavy duty ground stakes at both ends of the caterpillar.

The caterpillar cover is held in place by quarter-inch ropes over the top of the caterpillar which are secured to stakes or earth anchors in the ground. The edges of the plastic are left loose, with at least two extra feet on each side. When it's windy, the edges can be held down with rocks or sand bags. At the gable ends, the plastic is bunched together using rope, and the rope is tied to a secure stake. Caterpillars have to be manually ventilated. During cold periods, some edges of the cover can be held up with short Y-shaped props. When it's warmer, the covers can be rolled up all along the tunnel, using

clamps or taller props to hold it in place. The sides must be rolled down if it's going to get windy. These temporary structures will not withstand heavy snow or wind.

Low tunnels are smaller still, from 1 to 4 feet tall. They are essentially large row covers on some kind of large hoop. The size of the hoops and the covers can be as wide as needed to cover the beds to be protected. If used outside, low covers need to have the covers firmly secured with rocks, soil or sandbags. If the cover freezes to the ground in winter it is difficult to harvest crops inside a low tunnel. Low tunnels are also used inside a hoophouse or high tunnel for added thermal protection of winter-harvested crops such as greens or to help overwinter tender crops.

Payback. Given the right market for the crops they produce, tunnels have proven to be a good investment for many growers. Everything from cut flowers to raspberries is being grown in tunnels. Obviously, returns vary with prices, labor costs, growing conditions and management but for example, well-managed leafy greens or tomato crops have been shown to net $1-$3 per square foot annually, or more.

For more information on high tunnel enterprise budgets, construction and management, see: Cornell University High Tunnel site:
http://www.hort.cornell.edu/hightunnel/
Minnesota High Tunnel Manual:
http://hightunnels.cfans.umn.edu/minnesota-high-tunnel-production-manual/
Northeast High Tunnel Manual:
http://www.uvm.edu/~susagctr/resources/HighTunnels.pdf.

11-24-14

High Tunnel Cherry Tomatoes: Production and Economics of Tunnel Cherry Tomatoes at Green Gardens

Trent Thompson, Farmer, Green Gardens, trent@greengardensfarm.com

Brief Overview of Green Gardens

•Battle Creek, MI
•35 different crops
•4.5 field acres of vegetables, 25K sq. ft of high tunnels
•2-4 employees, 4 in summer months
•Selling Outlets:
Farmers Markets in Kalamazoo and Battle Creek
120-member CSA
Farm Stand at Farm
Five wholesale buyers (one food hub, 3 restaurants, Food-Co-op)

History of High Tunnel Cherry Tomatoes at Green Gardens

•Dominant Variety: Sun Gold (remarkable sweet, tangy, and delicious flavor)
•Addictive to customers
•Stand out in both retail and wholesale marketplace
•Good, consistent yields. Never had a bad crop
•Created a niche in market over time

Year	Number of Plants
2009	45
2010	90
2011	180
2012	180
2013	340
2014	468
2015 target	600+

2014: Timing for high tunnel cherry tomatoes

•3/1 - sow seeds in flats on heat mats (80-85F)
•4/5 - pot –up 4-5" tall plants into 50 cell plugs
•4/21 – plant 7-wk old plants into high tunnel
•5/5 – Pruned to two leaders per plant and clipped each leader to Tomahook twine. Pruning and twining continues for 10 weeks
•6/14 - 1st fully orange Sun Gold
•7/4 - 1st good harvest
•10/6 – Final harvest. Still a lot of fruit on plants!
•10/11 Plants are ripped out. Followed by winter spinach.

Cherry Tomato Plant Spacing

•6 rows per tunnel, 136 ft rows
•5 ft between rows
•4 rows at 2 ft between plants
•2 rows at 18" between plants (trial)
•468 total Sun Gold plants
•936 leaders

Cherry Tomato Soil Fertility

•30x144 ft tunnel (4320 square feet)
•Our soil: Sandy loam, 3.0% OM, pH 6.5, CEC 13
•Three 50 LB bags of 2-3-16, 60 LBS of sulfate of potash (0-0-50), 30 LBS Kelp, 100 LBS Hi-Cal Lime, 40 LBS Gypsum, Small amount of Borax
•Notice: We put down over 500 LBS/acre K. Trying to bank our K levels for high K demand.
•Side dressed plants with another 5 lbs potash/bed two times once in May and again in early June.

Fertility Issues

- Fruit was noticeably too small in early June. Decided to send tissue sample in.
- Results showed low K levels already
- Our sandy soil did not hold onto K and tomato demand for K in tunnels is very high.
- We had a hard time keeping up with K needs.
- Nitrogen also dropped quickly in between June and July.
- Side-dressing of feather meal and sulfate of potash along with fertigation of soluble potash and Neptune's Harvest 2-4-1 nursed the crop along

Ideal Tomato Nutrient Tissue Levels

•Tissue N levels should be at about 4% as fruit are developing. Higher levels can create soft fruit, more foliage, and fewer fruit.
•Tissue K levels need to be above 3% for tomatoes and peppers to produce the highest quality fruit and to keep creating new blossoms.
•Ideally Ca should be at about 3% and Mg at 0.8-1%. This prevents cracking and produces fruit that are tough enough for packing and shipping.

•Source: Steve Bogash, ***Banking Potassium: Getting A Bit Ahead On Tomato Consumption,*** **PSU Extension.**

Mid- July: Switched over to soluble K and Neptune's Harvest through fertigation

•Tri-weekly applications with Irrigation
•1 cup of 2-4-1 with 1 cup of Soluble Potash
•Fruit size and plant health seemed to improve
•Consistent harvests remainder of season
•Conclusion: Do tissue tests earlier. Build soil organic matter content with compost and/or spoon-feed crop consistently over entire season.

Tomato Pests

•The Tomato Hornworm
•Easy to control with Bt
•Sprayed Dipel DF two times in 2014 after early signs of caterpillar damage

Disease Prevention

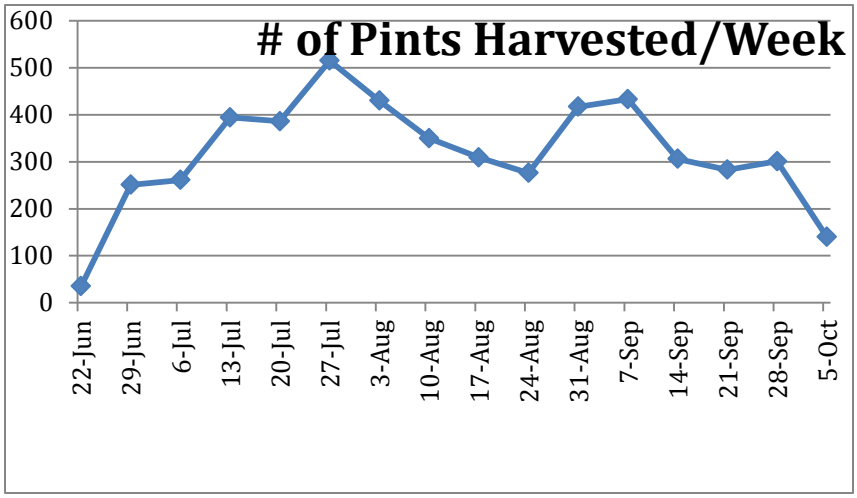
•Use Champ WG Copper Fungicide (copper hydroxide-based) from 2 weeks to 7 weeks in propagation house.
•Spray one time in high tunnel
•Do not spray again unless necessary
•Keep tunnels very well ventilated. Sides and end-walls are entirely open most of time May-Sept, including at night (unless below 50F).
•Prune early and keep pruning!

Irrigation

•1 line per row most of harvest season (low flow, .34 gpm/100 ft). 3 times per week for two hours. DO NOT water heavy. Will split!
•3 lines per bed when inter-cropping early in season
•Early heavy irrigation due to intercropping may have leached more soil nutrients than desired
•Used EZ-FLO fertilizer injector for 8 weeks with irrigation (soluble potash and Neptune's 2-4-1)
•Should have water pH tested

Yield, Summer of 2014

Week	# of Pints Harvested/Week
23-Jun	35
30-Jun	251
7-Jul	261
14-Jul	394
21-Jul	386
28-Jul	515
4-Aug	430
11-Aug	350
18-Aug	309
25-Aug	276
1-Sep	417
8-Sep	433
15-Sep	306
22-Sep	283
29-Sep	301
6-Oct	140
Total	5087 pints



Notes on Yield

- 10.86 pints per plant (5087 pints off 468 plants)
- Fruit on two rows spaced at 18" seemed smaller than fruit at 2' spacing. We never actually weighed fruit. This was visually noticeable at several points during season.
- Yield would probably have been higher if fertility was better
- With some minimal heating, this crop could have been carried into November

Revenues from 30x144 Sun Gold Tunnel

Revenue from Sun Golds

Outlet	Est. Avg Price	# of units sold	Revenue per Outlet
Wholesale	**$2.95**	**585**	**$1,725.75**
Farmers Market	**$3.30**	**2932**	**$9,675.60**
CSA	**$3.50**	**1050 (estimate)**	**$3,675.00**
Farm Stand	**$3.50**	**489**	**$1,711.50**

Total Unsold Pints	**Total Revenue**	**$16,787.85**
31	**Revenue per plant (468)**	**$35.87**

Notes on Revenue

- Opportunity to increase prices and/or expand Sun Gold planting in 2015.
- Only 31 unsold Sun Gold pints entire year. Price was probably too low most of season. Although, 3 for $9 or 3 for $10 deals helped us move 250+ pints at Farmers Market.
- In August and September, we also sold 50-150 pints per week of Sun Sugars from field. Quality and consistency of field Sun Sugars not as high as Sun Golds, but not having these would have driven up demand for Sun Golds more and allowed us to keep market price at $3.50.
- Over 20% of crop was essentially pre-sold to CSA
- Our market-style CSA made it challenging to track exactly if CSA customer or FM customer purchased Sun Golds.

Sun Gold Production Cost, 30x144

Fertilizer	Cost
2-3-16, 150 LBS	$60.00
Sulfate of Potash, 120 LBS	$96.00
Kelp Meal, 30 LBS	$24.00
Hi-Cal Lime, 100 LBS	$12.00
Gypsum, 40 LBS	$4.00
Borax, 1 LB	$1.00
Feather Meal, 30 LBS	$24.00
Neptune's Harvest, 2-4-1, 24 cups	$37.50
Soluble Potash, 24 cups	$25.00
Total Fertilizer Cost	**$283.50**

Task	Time (manhours)	Total Cost ($)
Growing Plants	10	$137.50
Tunnel Prep	2	$27.50
Planting	4	$55.00
Irrigation Set-Up	1	$13.75
Trellis Set-Up	4	$55.00
Initial Clipping and Pruning	3	$41.25
Weekly Irrigation	12	$165.00
Pruning and Trellising (10 weeks)	30	$412.50
Harvesting (9 hrs/wk x 16 weeks)	**144**	**$1,980.00**
Side-dressing, 4x	4	$55.00
Setting-up fertigation (24X)	3	$41.25
Weeding	8	$110.00
Spraying Bt, 2x	1	$13.75
Plant Removal and Clean-up	5	$68.75
Total Manhours	231	
Hourly Cost of Labor	$13.75	
Labor Cost		**$3,176.25**

Additional Costs

30x144 Plastic, Depreciated over 4 yrs	$200.00
Hoophouse Maint	$50.00
Marketing, Transport	$400.00
Propane, approx 10 tanks	$173.00
Tomahooks with Twine (3 uses over 3 yrs)	$80.00
Overhead Trellis wire (840 ft)	$150.00
Tomato Clips	$25.00
T-Tape and Emitters	$30.00
Additional Cost Total	**$1,108.00**

TOTAL COST of Sun Gold production in 30x144: $4,567.75

Sun Gold Verdict

•Sun Gold production in the 30x144 had a net profit of $12,220.
•Intercropping lettuce and basil with them added on another $1,000+ revenue
•Very labor-intensive crop
•Forgiving crop, but good fertility management will improve yields and profits
•Should raise prices and/or increase production in 2015 at Green Gardens
* Consider getting an earlier jumpstart with earlier planting date and/or more supplemental heating