

High Tunnel Selection and Construction Considerations

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Introduction

- What are high tunnels?
 - *High tunnels are passively heated and ventilated, plastic-covered structures that provide an intermediate level of environmental protection and control compared to open field conditions and heated greenhouses. (Source: Hightunnels.org)*

Differences between high tunnels and greenhouses

High tunnels

- Simple-low cost structure
- Passively heated and ventilated
- Usually one layer of plastic
 - Relatively low R-value
- Used for season extension
- In ground production
- Low operating cost
- Site may or may not need leveling

Greenhouses

- Higher initial investment in structure, utilities and equipment
- Heaters, fans and cool cells
- Higher R-values
 - Glass, multi layers of plastic with inflation
- Year round production
- Typically container production
- High energy consumption
- Higher maintenance operating cost
- Site will likely need leveling and/or construction of a pad

Differences between high tunnels and greenhouses

High tunnels



Greenhouses



Advantages of high tunnels relative to field production

- Season extension/off season production
- Reduced moisture on foliage from rainfall and dew
 - Lower disease potential
- Increased growth rates and production
 - Increased heat unit accumulation and retention
 - More even light distribution
 - Reduced plant stress
- Exclude insect pests and some animals
 - Plant health and food safety
- Controlled water application
- Higher quality products



Site selection considerations

- Available space (dimensions)
- Direction of prevailing winds
 - Natural and man made wind breaks?
- Sunlight and shade
 - Incidence of sun's rays
 - Tree lines and other structure
- Soil structure
 - Rock may prevent or alter installation of ground anchors
- Consider locating tunnel over soil with adequate texture, fertility and internal drainage

Site selection considerations

- Slope and external drainage
 - Prevent water infiltration from runoff
 - Will the site need to be leveled?
 - May choose high tunnel type that follows contour of the land
- Access to water for irrigation
- Ease of access to site
 - Transporting materials to and from the tunnel
 - Access to site and inside tunnel with equipment

Site selection and preparation



Suggested tools and equipment for high tunnel construction

- Cordless screwdriver, hammer drill and bits
- Sledge hammer
- 100' to 300' tape measure
- String level or transit
- Ladder
- Auger
- Level
- Lift or tractor bucket



- Pry bar
- Skill saw
- Metal cut off saw
- Nylon string
- Ratchet and appropriate sockets
- Duct tape
- Bracing
- Trailer for flat work surface and bench

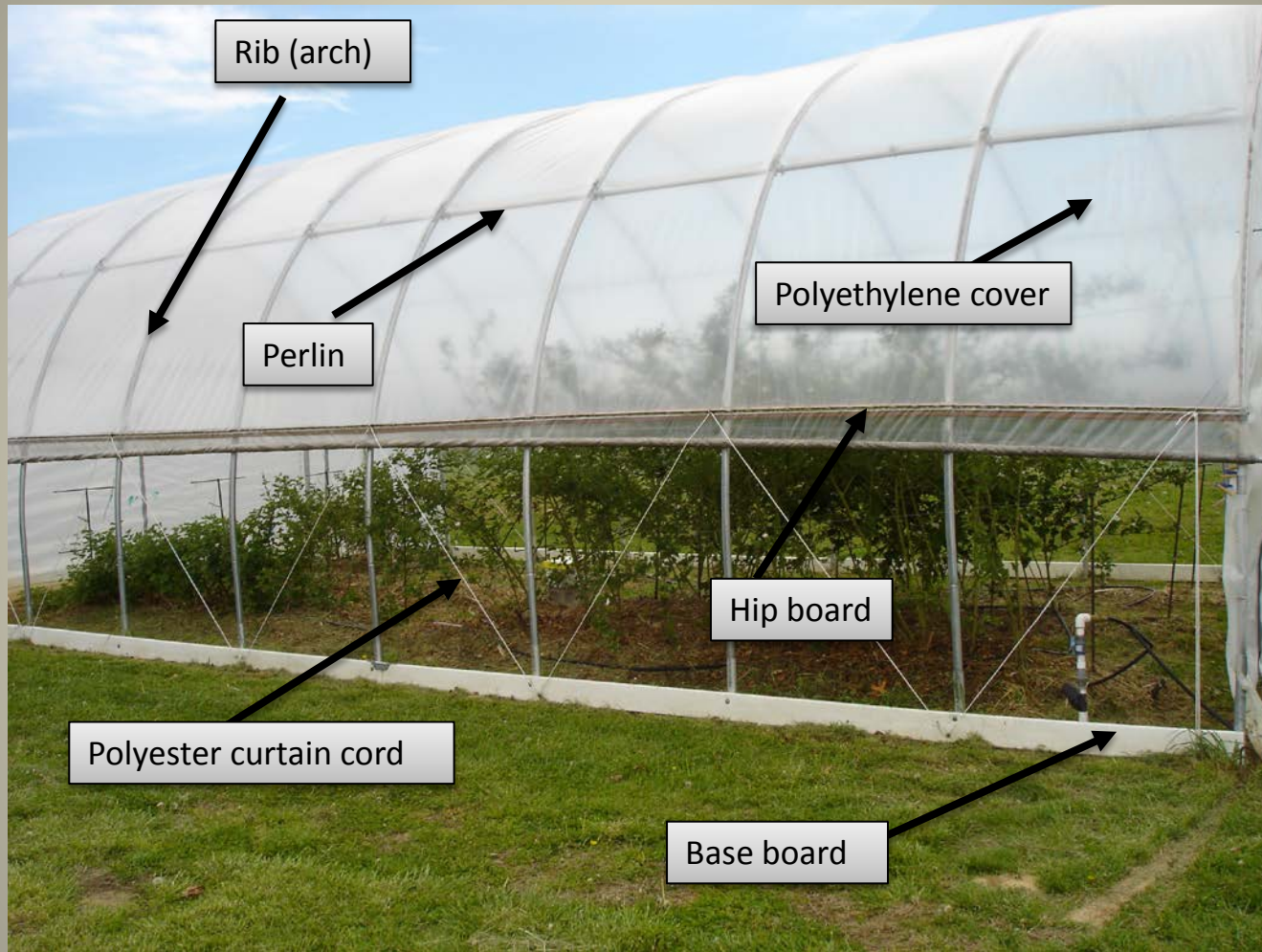


Components of high tunnels

- Most tunnels share three structural elements in common:
 - Steel hoops covered by greenhouse grade plastic
 - Passive ventilation through roll-up side curtains
 - Sited on field soil



High tunnel terminology



Grower decisions

- Types of tunnels
 - Stationary vs. movable
 - Single bay vs. multi-bay
 - Architecture types and utility
 - Manufacturers
- Plastic
 - Advantages vs. costs of various types
- Ventilation
 - Side walls (curtains)
 - End walls



High tunnel types

- Stationary Tunnel
 - Fixed location
 - Long term
- Movable Tunnel
 - Relocate
 - Seasonal rotation considerations



High tunnel types

Quonset (hoop-house) tunnels

- Single bay (structure is a single component)
- Composed of rounded steel arches that create a single bay that range 12-40 feet wide
- Arches are 11-12 gauge steel spaced 4-6 feet apart
- Two types of arches:
 1. Arches beginning at ground level give the tunnel a rounded structure
 2. Or the arches can sit upon straight, 4-6 foot-tall sidewalls
 - Add height and allow taller crops to be grown in the rows along the walls



High tunnel types

Gothic style tunnels

- Single bay
- Have peaked roofs
 - steeper roofs help manage snow loads
- Gothic high tunnels tend to be taller than hoop-house tunnels
 - creates a more stable temperature regime during warmer months
- Require additional bracing (purlins) to withstand winds



High tunnel types

- Multi-bay
 - Used to cover larger acreages
 - Consist of several spans of arches connected by gutters at the roof seams
 - Do not have purlins or braces and are not designed to withstand snow loads or high winds
 - Require removal of plastic during potential wind storms and offseason during periods of snow
 - Popular in Europe and California
 - Tall enough to cover fruit trees
 - Accommodate tractors and other large equipment



Pros and cons of high tunnel architectures

- Quonset
 - Rounded roofline of these structures provides more surface area for snow accumulation
 - Provide less space utility for using heavy equipment (tractors) and growing crops next to side walls
 - Least expensive
- Gothic
 - Taller structure provides more surface area for wind related damage but steeper roof orientation makes it easier to handle snow loads
 - Vertical arches on sides allow more space utility for using heavy equipment and growing crops next to side walls
 - More costly than quonset tunnels
- Multi-bay
 - Best for large scale production especially tree fruits
 - Provide good space utility and ease of access for heavy equipment
 - Plastic roof cannot be left on year round
 - Expensive

What should you choose?

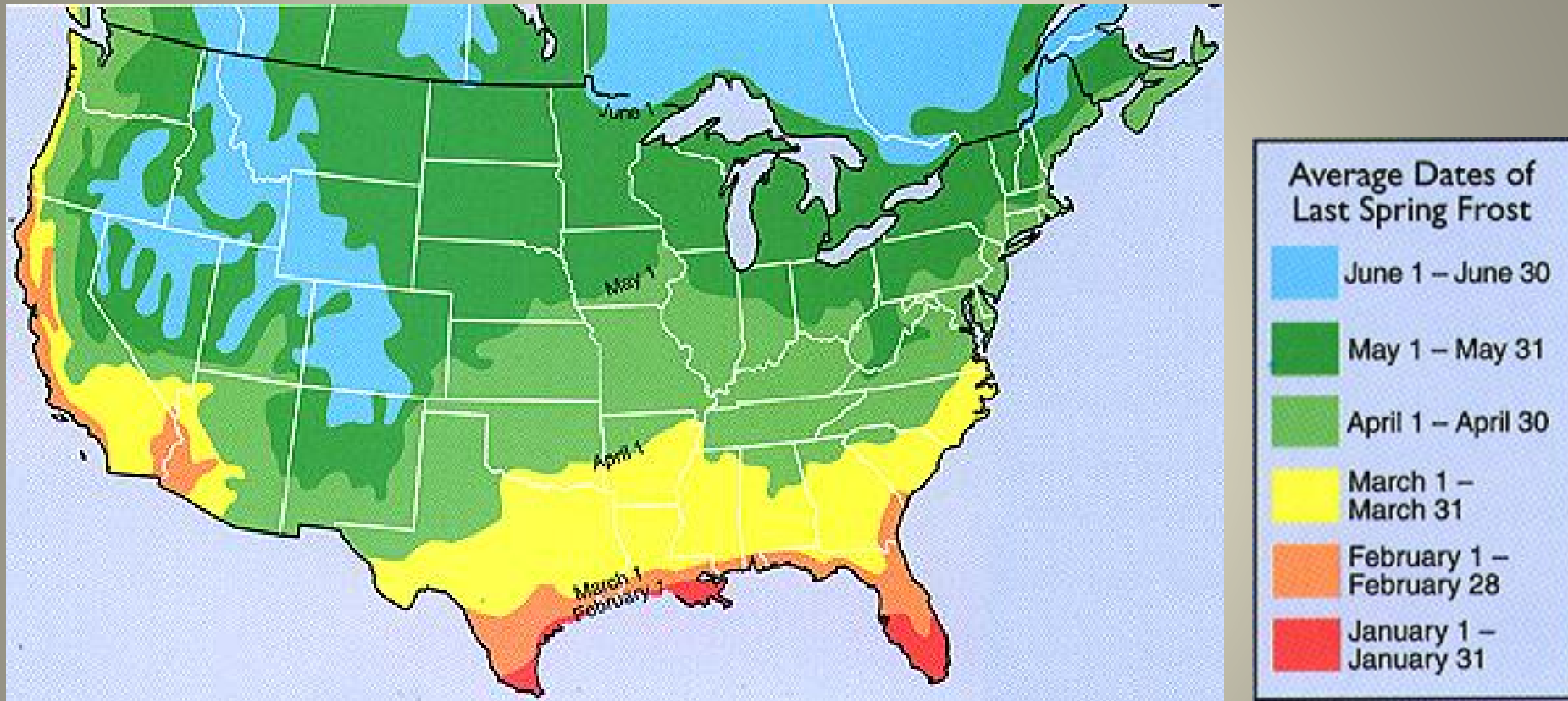
Considerations:

- **Size**
 - Narrower tunnels are easier it is to ventilate
 - A tunnel >30 feet wide may not have optimal lateral airflow for cooling
 - Taller, wider tunnels are more efficient at holding accumulated heat
- **Trellising**
 - Both single bay types (gothic and quonset) allow for vertical trellising (indeterminate tomatoes, cucumbers)
 - Multi-bay tunnels are better suited for crops that can be horizontally trellised (determinate tomatoes, peppers) or crops that need no trellis (strawberries)
- **Snow load/wind**
 - Gothic types are best for withstanding snow loads and wind compared to multi-bay tunnels
- **Mobility**
 - In-ground posts make stationary tunnels harder to move
 - Movable tunnels can be relocated to fresh soil annually
 - Crops can benefit from soil health and reduced disease and pests
 - However, movable tunnels carry greater risk of wind damage

What type of material should you use for the roof?

- Four to six mil, 4-year, greenhouse-grade polyethylene is suitable plastic for covering a high tunnel
- Infrared light additives provide excellent diffusion and absorb and re-radiate infrared heat back down to the crop during the evening hours
- Different types:
 - Standard types can range in light transmission 80-90%
 - Anti-condensate film is ideal for preventing water droplets from dropping on plants
 - Drip control additive is incorporated throughout the film
 - Prevents water droplets from falling on plants (disease)

Spring frosts by region



✓ One single layer of poly provides one hardiness zone of protection

High tunnel temperature control

- When to warm?
 - Evening until morning
- When to cool?
 - Morning until evening
- Why?
- Natural ventilation is BETTER
- Roll-up and drop down side wall systems SAVE MONEY
 - Temperature inside the structure can be maintained within a degree or two of outside during the warm season
 - Natural ventilation provides uniform temperature throughout the high tunnel
 - Opening the sidewall allows easy accessibility for moving plants into or out of the high tunnel

Ventilation

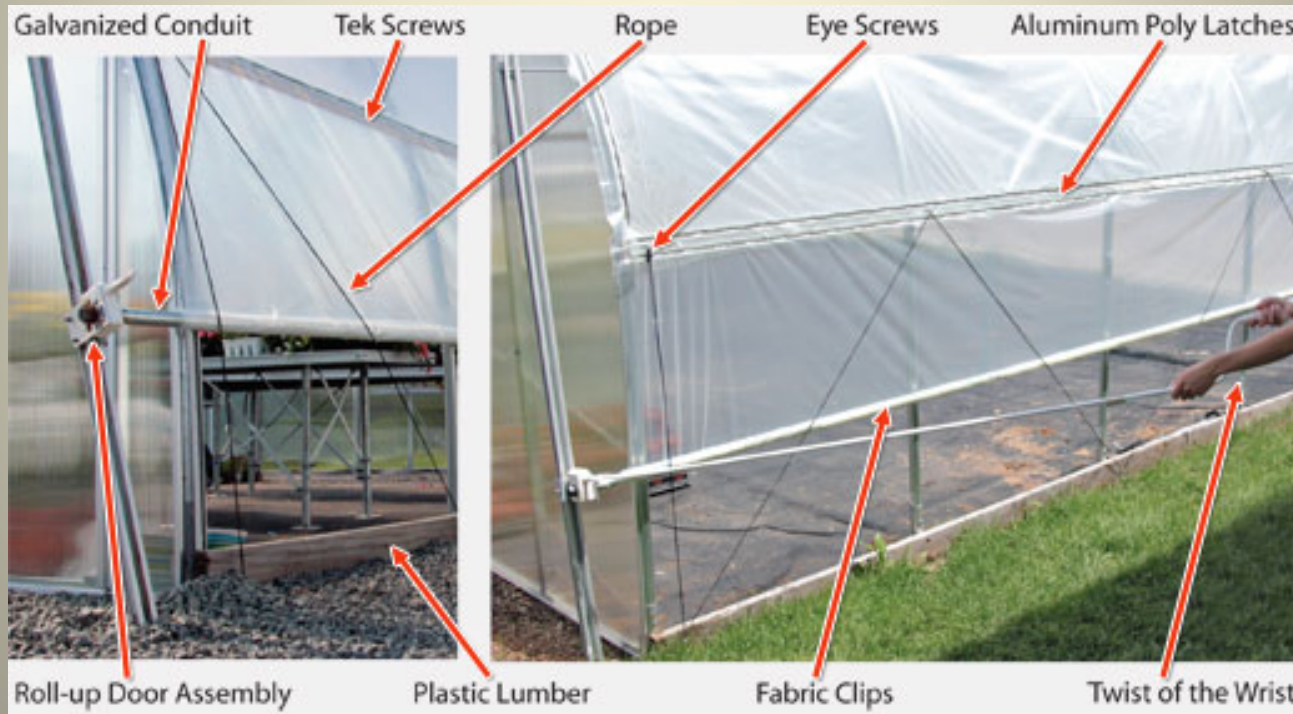
- Manually rolled side walls
 - Time consuming
 - Labor intensive
 - Inexpensive
 - Cost vs. time



Ventilation

Roll-up side walls

- Plastic is attached to a piece of steel tubing with clips
- To open the vent, the tubing is rolled up with a hand crank
- Opening the vent introduces cool air at the bottom or ground level of the tunnel
- Roll up side walls save time compared to manual system



http://www.growerssupply.com/farm/supplies/cat;10551;gs1_vent_openers_1;gs1_side_wall_curtain.html

Raising and lowering side walls

Drop-Down side walls

- Introduces cool air at the top of the curtain
- Allows it to mix with warm air and moderate before reaching the plants
- Bottom of the curtain wall material is attached to the baseboard and the top is attached to the steel tubing
- System of cables and pulleys attached to a manual winch is used to raise and lower curtain
- Curtain material can be a 4-year copolymer film or it can be a heavier material such as a reinforced polyethylene or polyvinyl
- Similar to ventilation curtains attached to poultry houses
- Roll up side walls save time compared to manual system



Raising and lowering side walls

- Manual- pushing the curtain up and lowering by hand
- Drop down system



End walls



End wall considerations

- Ease of access
 - Will heavy equipment be used?
- Type of material used
 - How long will it last?
 - Cost to replace
- Movable tunnel?
- Modifications may be necessary to suit your needs



Economic considerations for selecting high tunnels

*Pay for the tunnel fitting your specific production goals, management style and resources.....Consider....

- Crop type(s) and their management requirements
- Space requirement of crop (*Ex. Strawberries Vs. Cherries*)
 - Dimensions (L x W x H)
 - *Do you need a 15' high tunnel for lettuce and strawberries?*
- If trellising is secured to frame extra hardware and/or stronger structure may be required (*Ex. Tomatoes and Cucumbers*)
- Space available at site (may limit size of tunnel)
- Topography of the ground
 - Some models need relatively flat surface while others can follow contour of the land
- Will equipment be used in the tunnel?
 - May determine tunnel height, end wall/door type and side wall height

Economic considerations for selecting high tunnels

- Structural integrity of the tunnel structure and design as related to weather extremes
 - Wind and snow?
- Will customizations and extra material be needed?
 - These will likely add cost
 - Many tunnel kits require outside purchase of base board and end wall materials
- Cost of the tunnel and availability of funds for purchase
- Reasonable expectation of return over time
 - When will the “operation” break even?
- Construction labor costs are variable
 - Dependent on your experience
 - Size and complexity of the tunnel
 - Anchoring system and soil structure
 - Equipment available to aid in construction

Economic considerations for selecting high tunnels

Important: *Think of the tunnel expense(s) and revenue in terms of dollars per square foot under cover*

- Must manage to make best economic use of limited amount of space
- Rule of thumb: *Tunnel cost per square foot decreases as covered area increases*
 - Spread “fixed” costs over a larger area
 - Ex. End walls and doors
 - Extra height may cost more

Economic considerations for selecting high tunnels

Cost per Square Foot of High Tunnel Kits from Three Different Companies

Tunnel Brand/Model	Farmtek Round Style (Premium)	Farmtek Round Style (Premium)	Farmtek Round Style (Premium)
Dimensions	20'W x 12'H x 24'L	20'W x 12'H x 96'L	30'W x 12'H x 96'L
Square Footage	480	1920	2880
Total Cost	\$ 2,809.65	\$ 6,935.60	\$ 8,121.64
Cost per Square Foot	\$ 5.85	\$ 3.61	\$ 2.82

Tunnel Brand/Model	Farmtek Round Style (Economy)	Farmtek Round Style (Economy)	Farmtek Round Style (Economy)
Dimensions	20'W x 12'H x 24'L	20'W x 12'H x 96'L	30'W x 12'H x 96'L
Square Footage	480	1920	2880
Total Cost	\$ 2,421.60	\$ 5,919.09	\$ 7,123.46
Cost per Square Foot	\$ 5.05	\$ 3.08	\$ 2.47

Tunnel Brand/Model	Haygrove Super Solo	Haygrove Multi-Bay	Haygrove Multi-Bay
Dimensions	25 x 200	3 Bays 24 x 303 (.5 Acre)	15 Bays 24 x 303 (2.5 Acre)
Square Footage	5000	21816	109080
Total Cost	\$ 10,293.38	\$ 20,900.00	\$ 75,304.02
Cost per Square Foot	\$ 2.06	\$ 0.96	\$ 0.69

**Does not include labor cost.*

Economic considerations for selecting high tunnels

Business planning by the square foot

Scenario: Off season strawberry production under a Haygrove Super Solo High Tunnel(25 x 200)
Plant September 1. Harvest November through May.

Assumptions:

1900 strawberry plants.

5000 square feet covered area.

Tunnel cost per square foot **-\$2.06**

Cost of production per square foot **-\$0.71**

Season 1 tunnel + production cost per square foot **-\$2.77**

Average yield per plant- **1.5 lbs.**

Average price per lb.-**\$3.00**

Calculate:

Season 1 gross return per square foot **-\$1.77**

Season 1 profit per square foot **(-\$1.00)**

Season 2 carry over expense per square foot **-\$1.00**

		Season 1			
		Yield Per Plant (lbs.)			
		0.5	1	1.5	2
Price Per lb.	\$1.00	\$0.19	\$0.38	\$0.57	\$0.76
	\$1.50	\$0.29	\$0.57	\$0.86	\$1.14
	\$2.00	\$0.38	\$0.76	\$1.14	\$1.52
	\$2.50	\$0.48	\$0.95	\$1.43	\$1.90
	\$3.00	\$0.57	\$1.14	\$1.71	\$2.28
	\$3.50	\$0.67	\$1.33	\$2.00	\$2.66
	\$4.00	\$0.76	\$1.52	\$2.28	\$3.04
	\$4.50	\$0.86	\$1.71	\$2.57	\$3.42
	\$5.00	\$0.95	\$1.90	\$2.85	\$3.80
	\$5.50	\$1.05	\$2.09	\$3.14	\$4.18
	\$6.00	\$1.14	\$2.28	\$3.42	\$4.56
		\$ Yield/Square Foot			

First season profitability range

Economic considerations for selecting high tunnels

Business planning by the square foot

Scenario: Off season strawberry production under a Haygrove Super Solo High Tunnel(25 x 200)
Plant September 1. Harvest November through May.

Assumptions:

1900 strawberry plants.

5000 square feet covered area.

Carry over tunnel cost per square foot- **\$1.00**

Cost of production per square foot-**\$.80**

Season 2 tunnel + production cost per square foot -**\$1.80**

Average yield per plant- **2.0 lbs.**

Average price per lb.-**\$3.00**

Calculate:

Season 2 gross return per square foot-**\$2.28**

Season 2 profit per square foot- **\$.48**

		Season 2 Yield Per Plant (lbs.)			
		0.5	1	1.5	2
Price Per lb.	\$1.00	\$ 0.19	\$ 0.38	\$ 0.57	\$ 0.76
	\$1.50	\$ 0.29	\$ 0.57	\$ 0.86	\$ 1.14
	\$2.00	\$ 0.38	\$ 0.76	\$ 1.14	\$ 1.52
	\$2.50	\$ 0.48	\$ 0.95	\$ 1.43	\$ 1.90
	\$3.00	\$ 0.57	\$ 1.14	\$ 1.71	\$ 2.28
	\$3.50	\$ 0.67	\$ 1.33	\$ 2.00	\$ 2.66
	\$4.00	\$ 0.76	\$ 1.52	\$ 2.28	\$ 3.04
	\$4.50	\$ 0.86	\$ 1.71	\$ 2.57	\$ 3.42
	\$5.00	\$ 0.95	\$ 1.90	\$ 2.85	\$ 3.80
	\$5.50	\$ 1.05	\$ 2.09	\$ 3.14	\$ 4.18
	\$6.00	\$ 1.14	\$ 2.28	\$ 3.42	\$ 4.56

\$ Yield/Square Foot

Season 2 profitability range

Conclusions

- Evaluate tunnel costs and revenue by the square foot
- Consider crop type(s), management and revenue potential when selecting tunnels and accessories
- Remember high tunnels are not greenhouses
- Natural Resource Conservation Service (NRCS) has a program available 2013
 - Allows growers to apply for cost-share of high tunnels
 - Must meet requirements (no guarantee)
- Structural integrity
 - Snow and wind
- Consider insuring your structure
 - Why?

When disaster strikes!



Manufacturers

[Ledgewood Farm Greenhouse](#)

[Frames](#)

Rte 171

Moultonboro, NH 03254

603-476-8829

[Rimol Greenhouse Systems Inc.](#)

Northpoint Industrial Park

40 Londonderry Turnpike

Hooksett, NH 03106

877-746-6544

[Greenhouse Supply Inc.](#)

12 Acme Road, Suite 212

Brewer, ME 04412

800-696-8511

[Haygrove Tunnels](#)

694 Kraybill Church Road

Mount Joy, PA 17552

1-866-HAYGROVE

717-492-4955

harry.edwards@haygrove.com

[Farm Tek](#)

1440 Field of Dreams Way

Dyersville, IA 52040

1-800-327-6835

[Walker Bros, Inc.](#)

105 Porchtown Rd

Pittsgrove NJ,08318

856-358-6493

[Tunnel Tech](#)

1925 Windham Rd. 19

La Salette, Ontario N0E 1H0

519-582-4424

[Four Season Tools](#)

9615 Grand View Rd.

Kansas City, MO 64137

816-444-7330

steve@smallfarmtools.com

Other high tunnel suppliers

[M. Leonard](#) (Piqua, Ohio)

[Atlas Greenhouse Systems, Inc.](#) (Alapaha, Georgia)

[Conley's Greenhouse Mfg.](#) (Montclair, California)

[CropKing, Inc.](#) (Seville, Ohio)

[GothicArch Greenhouses](#) (Mobile, Alabama)

[Grow-It Greenhouse](#) (West Haven, Connecticut)

[Hoop House Greenhouse Kits](#) (Mashpee, Massachusetts)

[Hummert International](#) (Earth City, Missouri)

[International Greenhouse Company](#) (Georgetown, Illinois)

[Jaderloon](#) (Irmo, South Carolina)

[Keeler Glasgow](#) (Hartford, Michigan)

[Ludy Greenhouses](#) (New Madison, Ohio)

[Poly-Tex Inc.](#) (Castlerock, Minnesota)

[Speedling Inc.](#) (Sun City, Florida)

[Stuppy Greenhouse Mfg.](#) (Kansas City, Missouri)

[Turner Greenhouses](#) (Goldsboro, North Carolina)

[XS Smith](#) (Eatontown, New Jersey)

[Zimmerman's Welding](#) (Versailles, Missouri) 573-378-4770