Home High Tunnel Construction

A Hands-on Workshop Presented by the Cornell Vegetable Program

October 18, 2012

Bowman and Hill Micro Farm

Cornell University
Cooperative Extension
Cornell Vegetable Program

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Content Note

- There are many decisions to make before choosing to build a high tunnel.
- Topics covered in this presentation are limited to those directly related to tunnel construction.
- Related topics, theory, and specific tunnel use considerations are not discussed.
- Further planning information, as well as cultural/environmental management information and research results are available through the Cornell Vegetable Program.

Background

- This presentation is intended for use as a guideline for home construction of small high tunnels. It documents an October 18th, 2012, High Tunnel Construction workshop presented by the Cornell Vegetable Program (CVP).

- Many thanks to our workshop hosts and primary instructors Ken Bowman and Lyman Hill of Bowman and Hill Micro Farm. They operate a 12 acre greens farm and currently have 6 home-constructed high tunnels.

- The design and techniques presented are Lyman and Ken's experience-based adaptations of plans published by Johnny's Selected Seeds.

Background

The workshop participants helped build the farm's fifth tunnel. The house is 95' long x 12' wide x approximately 7' 1" high at the peak.

Participants gained experience squaring the site, bending pipes, erecting bows, attaching ridge poles/purlins, and preparing plastic anchoring. They also saw a ground post installation demonstration.

Due to wind conditions, attendees did not *glaze* (put the plastic on) the tunnel.

Previously constructed tunnels were used as models for glazing, end wall construction and troubleshooting discussions.

Lyman estimates that two people can build tunnel in 48 man-hours.

Note: While it is possible to build a tunnel by yourself, a helper will make several stages of construction much easier to complete.

Materials

Tools

Saw - circular or hack

Cordless drill - carbide tipped bits and extra battery/drill helpful

$^{9}/_{32}$" bit for boring holes

Small sledge hammer

Driving cap for ground posts

Hoop bender

Large crescent pipe wrench

Spare 2-3' long swedged end of pipe

Pliers

$^{7}/_{16}$" wrench

Pruning clippers

3 measuring tapes, 2 at least 100' long

Permanent marker

Plumb bob

Stone removal tools, if needed

Note: A large, flat, elevated working surface will make pipe bending easier.

Materials

Hardware

Screws – ¼” self-tapping for purlins, any type for end walls

20 pipe cross connectors - 1 $^{3}/_{8}$” x 1 $^{3}/_{8}$”

¼” (inside diameter) plastic tubing

¼” bolts, 4” long

¼” nuts & washers

Duct tape, 2 rolls

Hinges for 2 doors

Materials
Structural

Chain link fence

Ground posts: 6’ lengths of 1 ½” diameter – This tunnel: 20

Top rail: Bows, ridge pole/purlin: 1 $^{3}/_{8}$” diameter, tapered (*swedged*) at one end

This tunnel: 20 bows and 5 purlins, 21’ pipe including swedged end

C (wigglewire) channel - feet needed = 2 x (bow length – (2 x side opening height))

This tunnel: $2(21-(2\times 2.5)) = 2(21-5) = 32'$ (four 8’ long sections)

Wigglewire– See above formula - This tunnel: 32 feet (eight 4’ long pieces)

Polyethylene film, 6 mil greenhouse grade – sufficient to cover the tunnel

This tunnel: One 24 x 100’ roll

Paracord – One 1000’ roll

Plywood – approximately 6 sheets

2x4’s or 2x3’s – 1, 12’ long + 12, 8’ long

Note: Make sure the bows and ground posts are made of the same metal, treated with the same finish.

1x3 – 12, 8’ long. Optional: 6 additional 8’ boards for end wall plastic attachment

Wooden slats – 6-8, approximately 9”x1”. Height must be uniform.

Site Preparation

A good site is:

- Free of shade
- Level or slightly (% grade) pitched along the house's length
- Well drained, accounting for rain-shed volume, too
- Oriented appropriately with regard to prevalent winds and, for winter growing, low sun angles
- Sheltered from harsh seasonal winds
- Far enough from other structures to accommodate snow-shed volume and easy vegetation management
- Accessible in all seasons

Your site should meet all of these requirements before you begin construction

Ken and Lyman elect to form their permanent growing beds prior to tunnel construction. *It is far easier to amend the soil before the tunnel is standing.*

Design

- Pay close attention to local building codes and *structural stresses (loads)* when designing your house. A tunnel must endure snow loads, strong winds, and heavy crops.

- Closer bow spacing, deeper ground posts, corner bracing, additional purlins, bow cross-bars and hip boards can increase a tunnel's load bearing capacity.

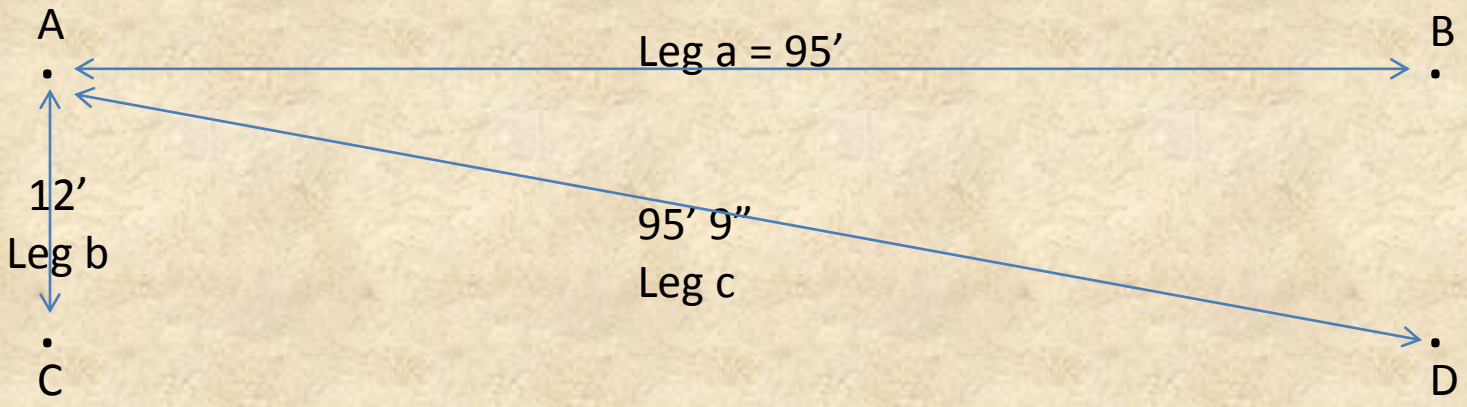
- Also consider ease of use factors such as vertical clearance, aisle space, and equipment accommodations.

- Ultimately, initial pipe length and the bender's *arc angle* will determine tunnel width and largely influence height.

- Height can be moderated by altering above-ground height of ground posts. Taller posts may require two bolts to anchor bow.

Squaring the Structure

1. Select the location for your first corner ground post (A)
2. Measure distance to corner post B (95’)
3. Measure the diagonal from post A to post D (95’ 9”). Leave tape anchored at approximate post D location
   Diagonal length = $\sqrt{a^2 + b^2}$
4. Measure distance from post B to post D (12’). Can use a 12’ board with a round, ¾” diameter notch in each end
5. Place post D at the intersection of the 12’ and 95’ 9” marks
6. The structure is square if there are exactly 5’ between the 3’ mark on Leg a and the 4’ mark on Leg b, for each corner (the 3-4-5 magic triangle)
7. Repeat steps 3-5 to locate post C



Squaring the Structure

Step 3: Measure the 95’ 9” diagonal from post A to post D

Step 4: Measure the short side with a tape.

Step 4: Notched 12’ board used to measure the short side.

Squaring the Structure

Step 5: Post D was placed at the intersection of 12’ and 95’ 9”.

Step 6: Check squareness of each corner using a 3-4-5 magic triangle

Helpful Tip:
The less slack in your measuring tapes, the easier it will be to find the true, or “square” intersection.

Caution: It is easy to rotate about a post and end up with sides that are not parallel and ends that aren’t perpendicular. Step 6 will catch those errors.

Ground Posts

Preparation

Ken and Lyman use 3’ long ground posts driven about 2’ into the ground with a bow overlap of 13”. They pre-drill the ground posts at 11”, for use later to anchor the bows and plastic. They prepare all posts before attaching any hoops.

This design calls for 1 bow every 5’.

Ground posts needed $= 2 \times (\frac{length}{\#bows} + 1)$

$= 2 \times (\frac{95}{5} + 1)$

$= 40$

Note: Generally speaking, deeper ground posts provide better anchoring of the tunnel and can be help reduce the structure’s *flight risk*.

Materials: Posts, saw, drill, measuring tape, marker

Step 1: Cut each 6’ post in half

Step 2: Use a permanent marker to mark 11” from one end

Step 3: Drill a hole straight through both sides at the 11” mark. The goal is to have a hole at 11” on the far side as well.

Step 4: Repeat for all remaining ground posts

Step 5: Once the corner posts are driven (see next slide), stretch tape from post A to post B

Step 6: Lay one ground post out every 5’ on center.

Ground Posts
Installation


Driving Cap

In this demonstration, all ground posts were hand driven using a driving cap and a small sledge hammer.

Corner posts should be completely driven (see below) before laying out other posts.

Finish driving all the posts on one side before moving onto the other. This improves driving consistency and leads to a straighter tunnel.

Materials: Ground posts, driving cap, sledge hammer, stone removal tools

Step 1: Tie a taught string around the ground posts to encircle the tunnel. The string will align with the outer edge of the corner posts and help you maintain a straight line of posts.

Step 2: Find a way to hold post vertical until it self-supports. Post should be inside of & flush to string.

Step 3: Place driving cap on post and carefully use hammer to tap post into ground until self-supporting.

Step 4: Check for vertical alignment and finish driving post. About 2' will be in the ground.

Step 5: Stop when the hole is just above the soil line. Stopping depth consistency and a level site will increase vertical evenness.

Note: Ken and Lyman have few stones in their soil. This technique may require modification in gravelly soils.

Ground Posts

Step 1: String is taught and lays flush with the exterior edge of the corner post.

Post about to be driven, with driving cap and pre-drilled hole. Steps 2 & 3: The post is flush to the string and vertical. Note that the distance between the hole and soil is about 2'.

Nicely driven post. Steps 4 & 5: The hole is just above the soil line. The post is vertical, flush to the string, and ~2' deep.

Ground Posts

Stage: Driving half-way completed

Left side: Completed

Right side:

- Nice straight line of posts!
- String flush to the outside, along whole edge
- First 2 posts driven consistently
- Driving cap on next post – not yet adjusted vertically
- Other posts already tapped in

Ground Posts

Ken prefers to drive one side of the tunnel deeper than the other. This helps “lean” the structure into the prevailing wind, which can reach 50^{+} mph on their farm.

This is the leeward side, so the hole is ~1” above the soil line.

On the windward side, the bottom of the hole is at ground level.