

2008

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## Recommended Citation

Black, B.L., D. Drost, D. Rowley, and R. Heflebower. 2008. Constructing a low-cost high tunnel. USU Extension Publication: HG/High Tunnels/2008-01pr.

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January 2008

HG/High Tunnels/2008-01pr

# Constructing a Low-cost High Tunnel

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## Site Selection

The high tunnel is designed for intensively managing a small area. Therefore, site selection is critical. The tunnel should be located in well-drained soils that are fertile and free of serious pathogens, weeds and other problems. The site should not be shaded, particularly on the south and west sides. The tunnel needs to be located near a year-round water source. This may require a freeze-free tap connected to a culinary water system in the winter. Access to power may also be beneficial. When constructing more than one house and the houses have an east-west orientation, separate them by about 10-feet so shading between houses is minimized.

To build a high tunnel you will need a circular saw, electric drill, drill bits, sledge hammer, a square, tin snips, and a 1/4-inch drill bit. Table 1 provides the materials list for tunnels that are 42, 90 or 140 feet long. Table 2 lists materials needed for constructing the doors. The following descriptions will assist you in building the end walls and doors, and in assembling the tunnel. While the end walls and doors can be constructed by one person, extra help will be needed to cover the tunnel with plastic and to help fasten the plastic to the end walls.

## Constructing the Tunnel End Walls

1. To construct the two end walls you will need two 16-foot long 2x4s, four 10-foot long 2x4s, and eight 8-foot long 2x4s.
2. Following the instructions below will construct one end wall as per Diagram 1. First, cut the lumber lengths as specified in Table 3 to minimize wastage. Start the end wall construction with part "A" and finish the construction with part "L."
3. Center and drill a 1/4-inch hole 1 foot from each end of the base plate "A." The rebar corner anchors and the end wall arches fit into these 1/4-inch holes.
4. Assemble parts "A" through "H" as shown on the end wall diagram. Start with board "A" and screw board "B" to board "A" using two 3-inch wood screws. Continue fastening board "C" and "D" making sure that the door opening is centered, the side walls are square and all boards fit together at 90° angles.
5. Attach parts "E" and "F" as outlined on Diagram 1, and then attach parts "G" and "H."
6. Lay boards "I" and "L" on top of assembled end wall and use a pencil to mark the angles (22° and 68°) from below. Make sure that there is a 1-inch gap between the 1/4-inch holes in part "A" and the attachment point between "A" and parts "I" and "L." While the two angles (22° and 68°) can be measured, the measurements do not need to be exact, so marking them with a pencil before cutting is easier than measuring the angles. Cut the correct angle, position them as illustrated in the diagram and fasten them

to the rest of the end wall with 3 inch screws.

- Lay boards "J" and "K" against assembled end wall and mark the two angles (47° and 43°) with a pencil from below as suggested in step 6. Cut the angles, position them as

illustrated in the diagram and fasten with 3-inch screws.

- Repeat steps 2-7 to construct second end wall.
- After building the walls, the wood can be protected with a coat of exterior grade latex paint, if desired.

Table 1. Materials needed to construct a high tunnel and their associated costs. Quantities and costs are presented for constructing tunnels 14 feet wide and in lengths of 42, 90 or 140 feet.

<u>Tunnel</u>	Quantity			Unit price	Cost		
	Tunnel length				Tunnel length		
	42'	90'	140'		42'	90'	140'
6 mil greenhouse plastic (24' wide) <sup>1</sup>	50'	100'	150'	\$2/ft	\$130	\$200	\$300
½" x 24" precut rebar for side anchors	30	62	96	\$1.09	\$32.70	\$67.58	\$104.94
1" schedule 40 PVC pipe - hoops	340'	700'	1080'	\$5.40/20'	\$102.60	\$216.00	\$324.00
-ridge purlin	40'	100'	140'				
PVC cement to glue arch pieces		1 pint		\$5.70		\$5.70	
Baling twine - lash frame, secure plastic (10' for each 1' of tunnel length)		available in 5000' roll		\$20.99		\$20.99	
White exterior latex paint to coat PVC hoops <sup>2</sup>	1 qt.	2 qts.	3 qts.	\$14.00/gal.		\$14.00	
<b>Tunnel subtotal</b>					<b>\$306.00</b>	<b>\$524.28</b>	<b>\$769.34</b>
<b>Endwalls</b>							
Lumber - 8 foot 2 x 4		8 lengths		\$1.98		\$15.84	
10 foot 2 x 4		4 lengths		\$3.27		\$13.08	
16 foot 2 x 4		2 length		\$5.84		\$11.68	
4' lathe		1 bundle of 50		\$9.78		\$ 9.78	
Wood screws - 3" construct wall		1 box		\$8.50		\$8.50	
1 5/8" to attach lath to endwall		1 box		\$8.50		\$8.50	
Plumbers hanger strap (attach last hoop and to support posts to endwall)		12'		\$3.26 25' roll		\$3.26	
White exterior latex paint		1 gal.		\$14.00		\$14.00	
Corner reinforcing brackets		16		\$ 0.70		\$11.20	
T-posts to support end walls		4		\$4.19		\$16.76	
				<b>End wall subtotal</b>		<b>\$112.60</b>	
				<b>Total excluding doors</b>	<b>\$418.60</b>	<b>\$636.88</b>	<b>\$881.94</b>

<sup>1</sup>Standard lengths for plastic are 100', 150' and 220'. Custom lengths are available but require a 30% surcharge.

<sup>2</sup>Paint requirement for end walls and hoops may exceed 1 gallon.

Table 2. Door options and associated costs per door

	Quantity	Unit price	Cost
<b>Option 1 - roll up curtain</b>			
Plastic	6' x 7'	left over*	
Lumber - 2x4 x 8'	1	\$1.98	\$1.98
4' lath	3	left over	
Baling twine to secure curtain to endwall	20'	left over	
Eye screws for baling twine	4	\$0.10	\$0.40
<b>Option 1 - cost per door</b>			<b>\$2.38</b>
<b>Option 2- Standard wood-frame door</b>			
Plastic	5' x 7'	left over	
Lumber - 2x4 8'	3	\$1.98	\$5.94
2x4 x 10'	1	\$3.27	\$3.27
4' lath	6	left over	
Hinges	2	\$1.08	\$2.16
Gate latch	1	\$4.00	\$4.00
Paint	left from end wall		
<b>Option 2 - cost per door</b>			<b>\$15.37</b>
<b>Option 3 - Top-venting wood frame door</b>			
Plastic	5' x 7'	left over	
Lumber - 2x4 x 8'	3	\$1.98	\$5.94
2x4 x 10'	3	\$3.27	\$9.81
4' lath	7	left over	
Hinges	4	\$1.08	\$4.32
Gate latch for main door	1	\$4.00	\$4.00
Bolt latch for top door	1	\$1.68	\$1.68
Paint	left from end wall		
<b>Option 3 - cost per door</b>			<b>\$25.75</b>

\*There may not be sufficient left over plastic to cover the door.

Table 3. Cutting instructions for 2x4 boards to construct one endwall.					
#	Length	Length	Part#	Length	Part #
1	16'	un-cut	"A"		
2	10'	5'	"C"	4' - 6"	"I"
		4' - 6"	"L"	(2) 2' - 6"	"E", "H"
2	8'	(2) 4'	"F", "G"	(2) 3' - 10"	"J", "K"
2	8'	(2) 6' - 5½"	"B", "D"		

### Constructing a Simple Frame Door

1. To construct one simple door to fit into the end wall openings you will need one 10-foot long 2x4 and three 8-foot long 2x4s.
2. Cut the 2x4 pieces to the lengths specified in Table 4 to minimize wastage, marking the pieces with the appropriate part letters as you cut them. Assemble according to Diagram 2. Start the door construction with board "a" and finish the construction with board "e."

Table 4. Cutting instructions for 2x4 boards to construct a simple door.			
#	Length	Length	Part
2	8'	(2) 6' - 3"	"a", "c"
1	8'	Un-cut	"e"
1	10'	(2) 4' - 8"	"d", "b"

3. Assemble parts "a" to "d" as shown in Diagram 2 using 3-inch screws. Make sure the boards fit together at 90° angles.
4. Lay board "e" against the assembled door. Align the edges of the board to the corners of the door, mark the angles from below and cut them to fit.
5. Attach board "e" with 3 inch screws.

6. After building the door, the wood can be protected with a coat of exterior grade latex paint.
7. Cover the door with a sheet of plastic, attaching the plastic around the door frame using lath strips and screws.

### Constructing a Door with Top Vents

1. To construct one top-venting door to fit into the end wall openings you will need two 10-foot long 2x4s and four 8-foot long 2x4s.
2. Following the instructions below will construct one door as per Diagram 3. Cut the 2x4 lumber to the lengths specified in Table 5 to minimize wastage. Mark the pieces with the appropriate numbers as you cut them. Start the door construction with part "AA" and finish the construction with part "EE".

Table 5. Cutting instructions for 2x4 boards to construct a top-venting door.					
#	Length	Cut length	Part #	Cut length	Part #
2	8'	(2) 6' - 3"	"AA", "CC"	(2) 1' - 6"	"HH", "KK"
1	8'	4' - 8"	"BB"		
1	8'	Un-cut	"FF"		
2	10'	(2) 4' - 8"	"DD", "EE"	(2) 4' - 4½"	"GG", "JJ"

3. Assemble parts "AA" to "EE" as shown in Diagram 3 using 3-inch screws. Make sure that all boards fit together at 90° angles.
4. Lay board "FF" on top of the assembled door. Align the edges of the board to the corners of the door, mark the angles from below and cut them to fit.
5. Attach board "FF" with 3-inch screws.
6. To open properly, the vent door must be beveled on one end. Cut an angle on one end of parts "HH" and "JJ" such that the front (outside relative to the door) of the board is 1 foot-6 inches and the back (inside relative

to the door) of the board is 1 foot-5½ inches (see side view of door vent: Diagram 3).

7. Assemble parts “GG” to “JJ” to make the vent door. Make sure that the shorter side of boards “HH” and “JJ” are facing the same way. When attaching board “GG”, it should be on a slant matching the angle of the upper cut surfaces of boards “HH” and “JJ.”
8. Insert the vent door into the vent opening on the door making sure that shorter angled edges of the boards are facing inward and upward. Attach the vent door to the main door with two hinges on the outside bottom of the vent door.
9. After building the top venting door, the wood can be protected with a coat of exterior grade latex paint.
10. Cover the door with a sheet of plastic, attaching the plastic around the door frame using lath strips and screws. A single uncut sheet of plastic can be used to cover both the vent door and the lower portion of the main door.

## Tunnel Assembly

Having built the end walls, doors and determined the location of your tunnel house, it is best to prepare the site prior to construction. Ground preparation can include deep plowing and tilling or rototilling. Prepare an area larger than the size of the tunnel.

1. Mark tunnel corners with rebar corner anchors. Measure diagonal distances to ensure that the layout is square. For example, for a 42-foot × 14-inch tunnel, the diagonal distances should be approximately 44 feet - 3½ inches.
2. Stand one pre-constructed end wall in place and insert rebar corner anchors through the drilled holes in the end wall base plate. One rebar corner anchors may need to be moved slightly so that the rebar is centered in the appropriate base plate hole.
3. Make sure the end wall is plumb, then drive a T-post into the ground at each edge of the door opening on the inward side of the end wall. T-posts should be driven into the soil so the top of the post is at a height of about 4 feet. Attach the end wall in two places to each T-posts using plumber’s strapping and

- 1 5/8-inch wood screws. Repeat this process for the opposite end wall making sure the corners are square and the walls are plumb.
4. Once the end walls are properly positioned and standing plumb, drive the rebar corner anchors 18-inches into the ground (leave 6 inches protruding above the soil line to anchor the PVC arches).
5. Tightly stretch baling twine along one side of the tunnel, and tie to rebar corner anchors posts to provide a guide for the 13 rebar side anchors. Starting at one corner lay out the rebar side anchors every 3 feet. Drive these rebar pieces 18 inches into the ground using the twine to keep the rebar side anchors in line with the corners. Remove the twine and repeat on the opposite side of the tunnel.
6. Cut 28 4-foot lengths and 13 22-foot lengths of baling twine. Tie a 2-foot length of twine at ground level to the 13 rebar side anchors along one side of the tunnel. Tie a loop in the free end of each of the 4-foot pieces of twine. Tie the 22-foot lengths of twine at ground level to the rebar side anchors on the opposite side of the tunnel. Position the twine pieces on the outside of the tunnel. The twine is used to hold down the plastic.
7. From two 20-foot lengths of PVC pipe, cut 15 28-inch long pieces. Assemble the 15 22-foot arches by gluing the 28-inch PVC pieces into the bell ends of 20-foot lengths of PVC using PVC cement.
8. After the glue dries, place each of the 15 PVC arches into position by sliding the pipe ends over the protruding ends of the rebar side anchors on opposite sides of the tunnel. The two end arches should slip over the rebar and fit into the 1-¼ inch drilled holes in the end wall base plates. The end arches should contact the end walls at each corner of the door opening and at the hip locations (Diagram 1). Fasten the end arches to the end walls at the hip and door corners using plumber’s strapping and 1 5/8-inch wood screws. To increase the life of the plastic cover, coat the outside of the PVC framework with latex paint, wherever the plastic will contact the framework.
9. Construct a “ridge purlin” by connecting the remaining PVC pipe end-to-end and cutting the last piece so that the purlin is the length of the tunnel. If the tunnel is to be portable,

the purlin pieces should be dry fitted (do not glue the pipes together). Attach the ridge purlin to the lower side of each arch at the peak on 3-foot centers. This can be accomplished either using 1 5/8-inch screws through pre-drilled holes, or by lashing the joint with the remaining 2-foot lengths of baling twine.

10. On a calm day, cover the tunnel with the 24 foot wide sheet of plastic. This works best if you have some help. A slight breeze can make this process more challenging, and a stiff wind will make it impossible. Unroll and unfold the plastic and pull it over the PVC framework. Square the plastic over the tunnels frame so that there are equal amounts of plastic on each end of the tunnel and approximately 1-foot of plastic contacts the ground along both sides of the tunnel. The extra plastic on the ends is used to cover the end wall to the door opening. It is helpful to use several of the twine pieces to tie down the plastic before you attach it to the end wall.
11. Excess plastic that covers the door openings will need to be removed once the plastic is centered on the tunnel. Leave about 6 inches of extra plastic at the door frame and baseboard. This plastic is wrapped around the lath strips.
12. Starting at one end, attach the plastic to the doorway opening using the 4-foot lengths of lath. Wrap approximately 6 inches of plastic several times around lath strip and fasten the lath and plastic to the door header using 1 5/8-inch screws. Next wrap and fasten the plastic to the door posts and finally attach the plastic to the base plate. Keep the plastic tight when securing the lath strips to the end wall.
13. Repeat step 12 on the opposite end of the tunnel house. Start by trimming off the excess plastic covering the door opening. After wrapping the plastic around the lath, pull the plastic as tightly as possible across the length of the tunnel house. Attach the lath to the door header using the 1 5/8-inch screws. Next wrap, stretch and attach the plastic to the door post being sure to pull the plastic tight. Finally, stretch and attach the plastic to the base-plate.
14. After attaching the plastic to the end frames, tie it down to the rebar side anchors using the twine. Stretch the 22-foot lengths of baling twine (step 6) over the top of the plastic and tie them to the 4-foot lengths of twine on the opposite side. Slip the end of the 22 foot- length through the loop eye, cinch the twine tight, and tie them together with a slip knot. The slip knots will need to be retightened periodically to maintain adequate tension on the plastic.
15. Cover the doors with plastic. Wind the plastic around a strip of lath and screw it to the door frame. Repeat on the opposite side of the door frame to create tension on the plastic. Attach the plastic on the top and bottom of the door frame. When attaching the plastic to the Top Venting Doors, attach the plastic to the side frames on the lower half of the door first, then attach the plastic on the bottom of the door before securing the plastic to the venting portion of the doors. If you attach the lath to the venting section of the door, it allows you to use only one piece of plastic which helps seal the hinging joint on the bottom side of the vent
16. Finish the tunnel by hanging the doors in the door openings using gate hinges. Alternatively, the door opening can be covered by a curtain-type door, consisting of a sheet of plastic, with a length of 2x4 attached to the base. This curtain type door can be rolled up and secured at the top of the door frame for ventilation.

## Structural Stability

This tunnel structure is designed as a low-cost alternative to more expensive engineered steel structures, thus it is not as sturdy. Care should be taken to close the side vents and doors when heavy winds are expected. We've also found that several support posts tied to the ridge purlin will provide temporary support for snow loads. We recommend brushing off the snow if more than 5 inches falls. With these precautions, our tunnels have withstood 45 mph winds and three Cache Valley winters.

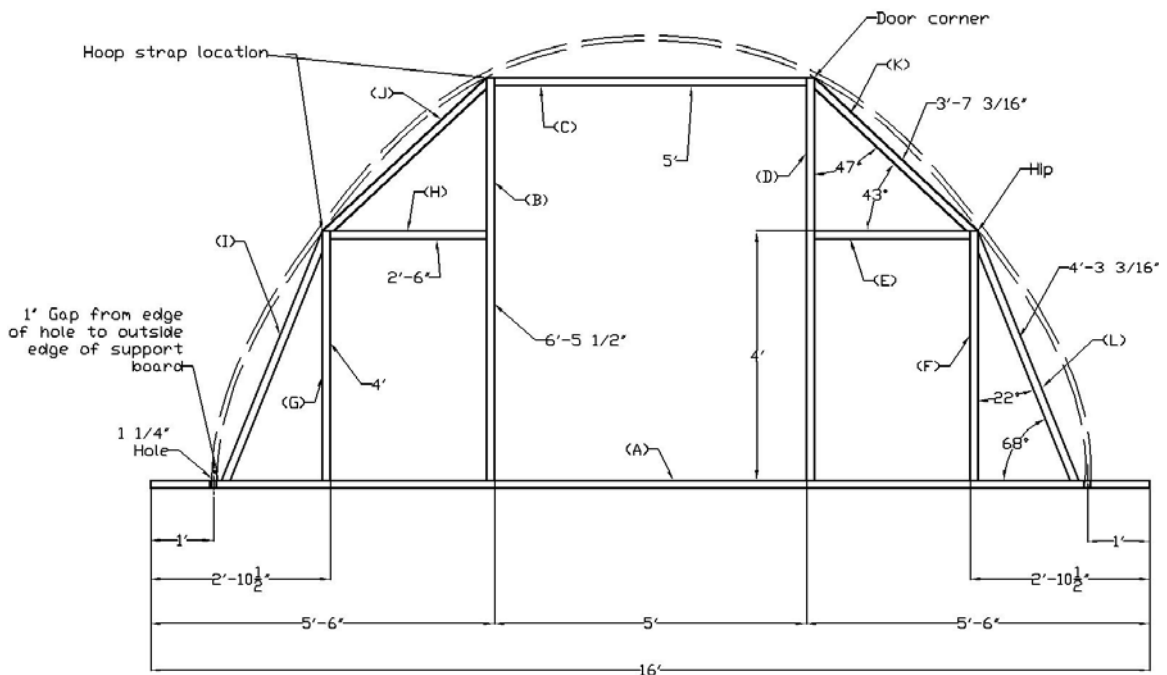


Diagram 1. End wall dimensions and part names.

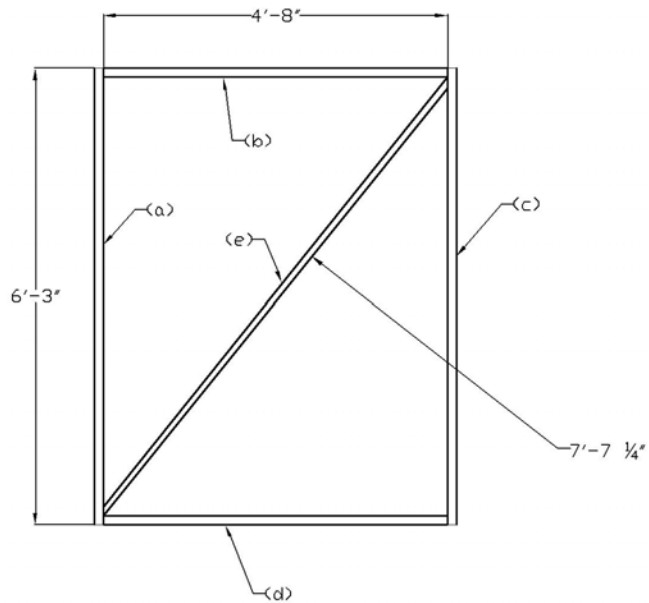


Diagram 2. Simple door.



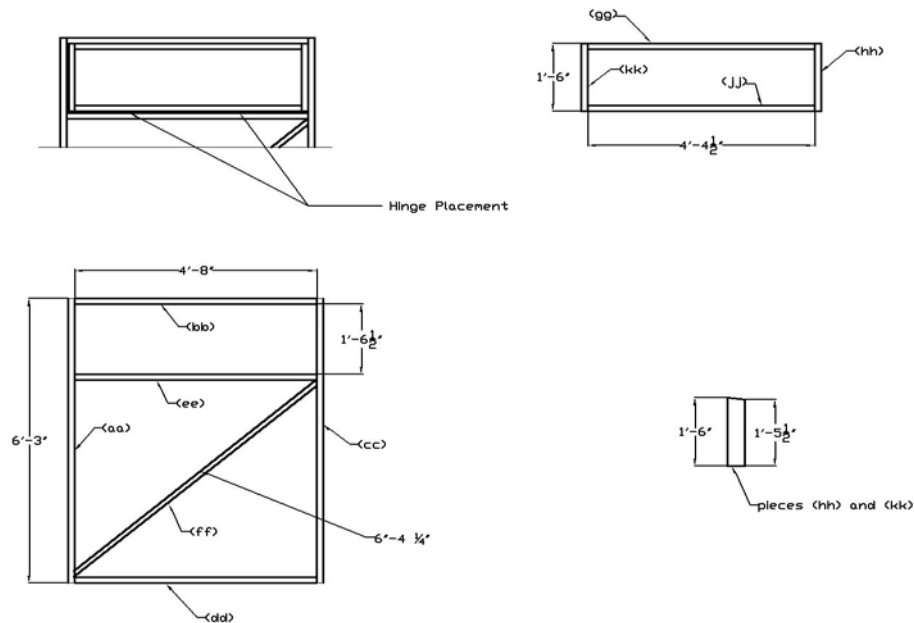


Diagram 3. Top venting door.

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This publication is issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Noelle E. Cockett, Vice President for Extension and Agriculture, Utah State University.