

Gothic Style High Tunnel Construction

2009 Wyoming State Fair Workshop

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17 ft. x 32 ft.

WYOMING SPECIALTY CROP PROGRAM



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2009

We would like to thank Del Jimenez of the New Mexico State University's Cooperative Extension Service for his time and expertise in high tunnel design, construction, promotion and educational outreach.

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Sincerely

Ted Craig
Agricultural Production Coordinator
Wyoming Department of Agriculture



Gothic Style High Tunnel Construction

17 ft. x 32 ft. Gothic Style Greenhouse

GOTHIC STYLE HIGH TUNNEL GREENHOUSE

The Gothic Style High Tunnel Greenhouse, is a cold frame hoop house but with changes to the design. The Gothic Style High Tunnel Greenhouse gets its name from its shape, and is constructed with straight lines using elbows to get the desired shape for the building. The shape of the Gothic Style High Tunnel Greenhouse causes water and snow to be shed from its exterior while permitting the sun's rays to provide heat. Houses in this category are made with plastic PVC pipes as ribs that are covered with a single layer of polymer plastic covering. A second layer maybe added for better insulation when using a fan to push air between the plastic layers.

REASONS TO BUILD GOTHIC STYLE HIGH TUNNEL GREENHOUSE

Gothic Style High Tunnel Greenhouses are ecosystems all in themselves and the environment inside can be manipulated to a crop's need. Gothic Style High Tunnel Greenhouses can extend the growing season, since you can plant early, the collection of heat units with the plant is higher resulting in earlier harvesting. Planting in late summer and early fall allows you to produce and harvest into the fall and winter months. Planting in a protected environment guards the crop from Mother Nature's whims and control the crop's quality. Using the hoop house for season extension increases income over a longer period of the year and allows the use of different marketing strategies.

FACTORS TO CONSIDER BEFORE BUILDING A GOTHIC STYLE HIGH TUNNEL GREENHOUSE

Gothic Style High Tunnel Greenhouses are relatively inexpensive to construct, costing around \$1 per square foot, with low maintenance once constructed. They are easy to build and adapt to small land units to meet the needs of gardeners and farmers. Since plants need sunlight to grow, light penetration should be a concern in structure design. Grow lights can be used but require an electrical source. In an area where wind and snow are part of nature, consider the load limitations the structure must have to endure stress. The height of the Gothic Style High Tunnel Greenhouse can be adjusted so that one can walk and work inside comfortably, therefore, one must think about height before construction starts.

SELECTING A SITE FOR A GOTHIC STYLE HIGH TUNNEL GREENHOUSE

Select a site that is moderately level with good drainage and good soil for planting. A site can be modified by soil fill so that construction is on a pad. Select a site in an open area where trees and other obstacles will not affect sun penetration. Consider the surrounding area so the structure will be protected against high winds and heavy snows, thus providing longer life. Water and electricity maybe needed for the hoop house, so a source nearby should be considered. Security and protection against vandalism of the Gothic Style High Tunnel Greenhouse and crop may also be a factor to consider when selecting a site.

ORIENTATION OF THE GOTHIC STYLE HIGH TUNNEL GREENHOUSE

Preferably, position the Gothic Style High Tunnel Greenhouse in a north↔south direction. Air currents come from a south, southwest direction and will help ventilate the hot air buildup within the hoop house on hot days. The north↔south orientation also favors sun penetration, since the sun tracks from east to west going directly over the hoop house for maximum light penetration.

LAYING OUT THE GOTHIC STYLE HIGH TUNNEL GREENHOUSE

Begin by choosing the size of a hoop house that meets your needs. Then square off the corners of the Gothic Style High Tunnel Greenhouse using the

Pythagorean Theorem.

$$A^2 + B^2 = C^2$$

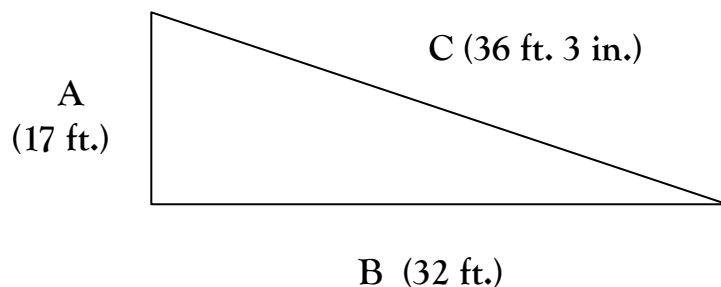
$$(\text{Length of Building})^2 + (\text{Width of Building})^2 = (\text{Hypotenuse of Building})^2$$

$$\text{Example: } A (17 \text{ ft.})^2 + B (40 \text{ ft.})^2 = C^2$$

$$289 \text{ ft.}^2 + 1,024 \text{ ft.}^2 = 1,313 \text{ ft.}^2$$

$$\sqrt{1,313} = 36.23 \text{ ft.}$$

$$C = 36.23 \text{ ft.}$$



Squaring the building is critical so that the rest of the structure proceeds normally in construction.

SETTING STAKES

After squaring the corners of the Gothic Style High Tunnel Greenhouse, mark by setting four stakes in the ground at each corner using ½-in. rebar 24 ins. long. Drive these stakes 12 ins. into the ground at a 30-degree angle from vertical pointing inward. Half the stake will now be underground and half the stake above the soil. Place a string around the four corners to outline the Gothic Style High Tunnel Greenhouse foundation.



Along both lengths of the Gothic Style High Tunnel Greenhouse and inside the string, drive 24 in. rebar stakes every 4 ft. apart, 12 in. deep, at 30 degree angles, until you reach the desired length.

MAKING THE PLASTIC PIPE RIBS

We recommend the use of 2-in. PVC in making the ribs, because it holds up well to the stress of wind and snow that come in the fall and winter. Use new plastic pipe for construction because weathered pipe will be brittle and break. The standard length for PVC pipe is 20 ft. length. From nine (9) pipes you will cut two (2) pieces 7 ft. 6 in. long and one piece 5 ft. long.



This will give you 18 pieces 7 ft. 6 in. long which are the rafters and 9 pieces 5 ft. long which are the legs. You need to cut 9 more legs that are 5 ft. long to give you a total of 18 legs. Using a 2 inch elbow with a 45° curve connect one rafter that is 7 ft. 6 in. long and one leg 5 ft. long using primer and glue. When finished you will have 18 primed and glued pieces.



On a flat surface connect two of the 7 ft. 6 in. rafters together using a 2 inch elbow with a 45° curve. This will give you one rib for your straight line cold frame that is made up of 3 elbows of 2 inches, 2 legs 5 foot, and 2 rafters that are 7 foot 6 inches long. After priming and gluing all the pieces together you will have 9 ribs.

Set the ribs over the rebar stakes. This is accomplished by placing one end of the PVC pipe over one of the stakes, Next place the opposite end of the pipe on the lateral stake on the opposite side.





If the rebar stakes are perpendicular to the ground, it is very difficult to place the pipe on the spike. That is why stakes should be placed at a 30-degree angle. Place all 9 ribs on the stakes.

INSTALLING LATERAL TUBULAR BRACES

There are three (3) tubular braces running the length of the inside of the hoop house that will be used for stability and also for irrigation. The tubular braces will be made from $\frac{3}{4}$ inch PVC pipe. PVC pipe comes in 10 or 20 ft. lengths. Connect lateral tubular pipes to measure 32 foot. Prime and glue the $\frac{3}{4}$ in. PVC pipe together and mark every 4 foot.



These markings will correspond with the distance between each of the 2 in. ribs. Start attaching the tubular braces from the front of the hoop house. Make sure the brace is flush with the outside of the first rib, and that the markings should coincide with each other. Attach the pipe above the 2 inch 60° elbows.



If you are not using the tubular braces for irrigating, you can attach the tubular brace directly to the 2 in. pipe using a 2-in. decking screws. If you will use the tubular brace for watering, you must use a $\frac{3}{4}$ -in. one-hole or two-hole conduit clamp to attach the pipe.

INSTALLING THE MIDDLE LATERAL TUBULAR BRACES

The third tubular brace will be put inside on top in the middle of the hoop house and will also be used for stability and irrigation. Cut 5 pieces of $\frac{3}{4}$ inch PVC pipe 6 foot in length. Using glue connect the five joints to 6 plastic tees $\frac{3}{4}$ inch. Make sure tee all point in the same direction.



Add 18 inches of $\frac{3}{4}$ inch PVC pipe to each side. Mark this pipe every 4 foot part and attach the tubular braces to the top of the structure using conduit clamps. Cut off

PLACING THE SIDEBOARDS

Sideboards are installed to give the hoop house stability, support for the plastic covering, and is also where the plastic cover is attached. The sideboards are made with 2 boards that are 1 in. x 4 ins. x 10 ft. long, and 1 board that is 1 in. x 4 ins. x 12 ft. long.



The 10 foot boards are on the outside and the 12 foot board is in the inside. With a brace splice the wood together. There are 3 sideboards per side. Place a side board on the ground at the end of the legs.

Make sure when putting on the sideboards that the screw tips are pointed downward. Attach the sideboards to the 2 inch plastic pipes using 2 inch screws. Place the first sideboard under the 60° elbows of the legs.





Place another sideboard half way in the middle of the rafters, the length of the building. Secure the bottom side board to a 2 inch plastic pipe.

SECURING THE COLD FRAME

On the inside of the Cold Frame at the bottom attach 1 inch x 4 inch wood 4 foot long to the frame using 2 inch screws. Put these boards between the 2-3 rib, 5-6 rib, and the 7-8 rib on each side.



When boards are in place, drive two 24 inch. Rebar stakes bent in a "J" design over each board. This will help keep the hoop house anchored during high velocity windstorms. Repeat process on other side.

DOOR FRAMES

At the end of each wall, door frames will be added to hold the doors. Doors are used to access the building, to open for air circulation, and to release the heat from inside. Measure and find the center of your end wall.



From the center measure two foot on each side and mark where a hole will be dug 18 inches deep. Inside the hole place a 2 inch x 4 inch x 10 feet. Cut to size so that the board comes under the plastic pipe. Using a post level, align and set post.

Drill through the 2 inch pipe on top and secure board using 4 inch screws.





On the ground set a 2inch x 4 inch board from the door frame to the structure. Secure these boards by using 3 inch screws. This board gives support to the hoop house and the plastic will also be attached to it.

Put a header between the door frame the height you wish your door to be.



The structure is now ready to be skinned.

ATTACHING POLYETHYLENE GREENHOUSE PLASTIC COVERING

The greenhouse plastic acts as the skin to the structure, letting light rays in and keeping the weather out. There are different makes and grades of poly covering, but a 6-ml. weight works well for hoop houses. It is recommended to use polyethylene coverings that have been treated with a UV inhibitor that is guaranteed to last at least four years. Unprotected polyethylene plastics will break down over a growing season. Greenhouse plastic coverings come in rolls 100 ft. in length and in widths ranging from 12 ft. to 52 ft. The length of the pipe that makes the hoop determines the width of the plastic covering, and it is recommended to add at least a foot on each side of the house width. To successfully apply the plastic covering, take the following steps: have extra labor available; make sure there's no wind; and work in the afternoon when the plastic can heat up and stretch.



Lay out the greenhouse plastic in a clean work area alongside of the hoop house, so you can measure and cut the plastic to the size required. Using a knife or scissors cut the plastic the length of your building plus the length of each end of your building with a one foot overlap on each side. After the plastic is cut, find the edge of the cut piece of poly and center it over the hoops by dragging gently across the top. Let the plastic rest on the hoops for at least 15 minutes to absorb the heat.

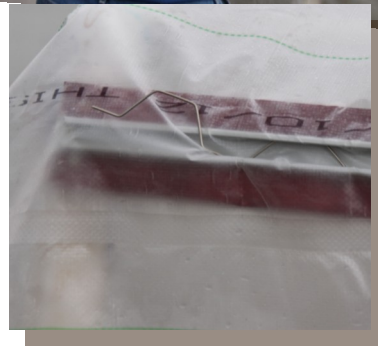
Keeping the plastic stretched; attach one side starting in the middle of your hoop house by sandwiching the plastic poly covering between a ¼ -in. x 2-in. x 8-ft. long furring strip onto the baseboard,





These furring strips can be cut out of a 2 x 4 inch board and driving 1-in. screws every 2 ft. (By using screws in the baseboard, it is easy to remove or replace plastic covering at a later date)

U channel and wiggle wire can also be used although it is more expensive. When one side is complete, attach the opposite side in the same manner.



When complete, shovel dirt onto the extra plastic at the base of the hoop house. This will keep wind and the draft from entering the hoop house.



On the ends, stretch the plastic tight over the 2 inch plastic pipe and sandwich the plastic poly covering between the $\frac{1}{4}$ x 2 inch furring stripping and the pipe using 1 inch screws.

ATTACHING POLYETHYLENE PLASTIC COVERING TO THE END WALLS

Bring the polyethylene covering over the hoops and attach along the door frame using furring strips and making sure the plastic is smooth using 1 inch screws.



Pulling your plastic covering outward attach the plastic on the bottom to your 2 inch x 4 inch boards using furring strips. For the corners tent and cut the plastic in a flag shape. One of the flags will go into the inside and the other flag will be on the outside.

Attach to the plastic pipe using furring strips. Do this to each corner. Over the top of the roof stretch the plastic out tent, cut and flag the plastic. Remove the furring strip that is holding the plastic down. Put one of the flags inside and the other outside of the hoop house. Reattach the furring strip over both plastics. Repeat on all four sides. Cut excess plastic flag off.



Cut the plastic out of the door frame and set aside until making the door. On the bottom of the hoop house cut all excess plastic to 1 foot out and remove the rest.

Making the Doors

Measure the high the of your door, then subtract 1 inch from that number and cut two 2 inch x 4inch boards to that length. Measure the width of your door then subtract 4 ½ inch from that number and cut three 2 inch x 4inch boards to that length. These boards go between the larger 2 inch x 4inch boards. Square the frame and set corner braces.



Using the cut out plastic from the door frame attach this plastic using furring strips.



Attach two 3 inch hinges to the side of the door and hang the door in the door frame. On the inside of your hoop house door frame attach 1 inch x 4 inch boards. This will keep air from entering around your door.



Conclusion

Hoop houses are practical tools to extend growing seasons and can be made to the size you require by adding or subtracting plastic ribs. During the winter months hoop houses can get to 80° F during the day and can drop to outside temperatures at night without a heat source. During the summer temperatures can reach 130° F during the day if not ventilated. There is a learning curve when working with hoop houses but the practice of learning can be enjoyable and beneficial with the production of food.

Gothic Style High Tunnel Construction

Material List and Estimated Cost (3/2010)

17 ft. x 32 ft. Gothic Style Greenhouse

<u>Item</u>	<u>Cost</u>	<u>Quantity</u>	<u>Total Cost</u>
1. Plastic PVC Pipes 2 in. x 20 ft. / Schedule 40	22.00	12	\$ 264.00
2. Plastic PVC Pipe ¾ in. x 20 ft. / Schedule 40	10.00	5	50.00
3. Rebar ½ in. x 24 ins.	1.60	36	18 St. 8 J Hook 10 Tie Downs 57.60
4. Plastic 2 in. PVC 45° Elbows	1.60	27	43.20
5. 2 Hole Conduit Straps ¾ Pipe Straps	0.25	27	6.75
6. Glue / Primer Set 16 oz.	20.00	1	20.00
7. Screws (Drywall Screws) 1 in. Box 150 Screws (1 lb.) 2 in. Box 150 Screws (1 lb.) 4 in. Box 150 Screws (1 lb.)	6.00 6.00 8.00	2 1 1	10.00 5.00 7.00
8. Wood Boards 1 in. x 4 in. x 10 ft. 1 in. x 4 in. x 12 ft.	7.00 8.00	12 7	84.00 56.00
9. Plastic Cover (6 mil) 28 ft. x 100 ft.	300.00	½	150.00
10. Ply Wood ½ in. x 4 ft. x 8 ft.	17.00	2	34.00
11. Wood Studs 2 in. x 4in. x 10ft.	3.50	15	52.50
12. Hinges	2.00	4	8.00
13. Latch	3.50	2	7.00
14. Paint	20.00	2	40.00
15. Poly Rope ¼ inch x100 ft.	9.00	3	27.00
Sub Total			\$ 922.05

Gothic Style Construction Design

For Roll Up Sides

16.	Plastic PVC Pipes 2 in. x 20 ft. / Schedule 40	22.00	4	\$ 88.00
17.	Plastic 2 in. PVC 90° Elbows	1.60	4	7.40
18.	Plastic 2 in. PVC Tee	2.50	4	10.00
19.	Rebar $\frac{3}{8}$ in. x 18 ins.	1.60	4	7.40

Sub Total \$ 112.80

For Irrigation System

20.	Plastic Tee Joints $\frac{3}{4}$ Slip Tee / Schedule 40	0.40	6	2.40
21.	Male Reducer Bushing $\frac{3}{4}$ - $\frac{1}{2}$ ($\frac{1}{2}$ Side Threaded)	0.50	6	3.00
22.	Plastic PVC Pipe $\frac{3}{4}$ in. x 10 ft. / Schedule 40	2.50	1	2.50
23.	PVC Spray Nozzles 360° $\frac{1}{2}$ inch	1.00	3	3.00
24.	PVC Spray Nozzles 180°	1.00	2	2.00
25.	PVC Ball Valve $\frac{3}{4}$ inch	3.00	1	3.00
26.	PVC Hose Connector $\frac{3}{4}$ inch	1.50	1	1.50
27.	End Cap $\frac{3}{4}$ inch	0.35	5	1.75
28.	Plastic $\frac{3}{4}$ in. 90° Elbow	0.30	1	0.30
29.	Plastic $\frac{3}{4}$ in. 45° Elbow	0.30	1	0.30

Sub Total \$ 19.75

Total Cost \$ 1,054.60