

HIGH TUNNEL GREENHOUSE FIELD CONSTRUCTION MANUAL



CONTACT INFORMATION

ACKNOWLEDGEMENTS

This manual would not have been possible if it was not for the following persons and organizations that put a lot of energy, time, and commitment into the collaboration and construction of the first ever High Tunnel Houses (HTHs) in Jamaica:

Mr. Weston Moses, Chief of Party, JA FARMS project, thank you for your energy, commitment, and comments on the drafts of this manual

USAID Global Development Alliance program for your time and financial support

Partners of the Americas, Farmer-to-Farmer programme for help supplying the technical assistance to make this a success, financial support, and believing in me to write this manual.

The United Nations Development Program, Small Grants Project for financial support.

Thank you to the Citizens Development Corps and the Maryland Hawk Corporation for their management and technical support.

A big thanks to Dan Kuennen, Executive Director, Maryland Hawk Corporation and Director, Rural Development Center, University of Maryland Eastern Shore for wonderful and concise comments on the drafts of this manual.

And of course, the Santoy Farmers' Co-operative members who put a lot of time into making this a complete manual: Mr. Devon Griffiths (Marcus), Mr. Milton Murdock, Mr. James Grant (Bravo), Mr. Eric Black, and Mr. William Parkins, thank you for your hard work, support and collaboration on this project.

PREFACE

This field manual is intended to guide in the construction and covering of a High Tunnel House (HTH) using bent steel hoop frames. The construction method is based on the field experience of the Santoy Farmers' Co-operative with training from the Maryland Hawk Corporation (MHC) in Hanover Jamaica. ***It does not, however, include information on the pipe bending technology used for the steel hoop frames.***

HTHs are a relatively new technology introduced to Jamaica by the Maryland Hawk Corporation and affiliated non-profit organization of the University of Maryland Eastern Shore in cooperation with the USAID Global Development Alliance, United Nations Small Grants Programme (GEF), and Partners of the Americas Farmer-to-Farmer program through the *Jamaica Farmers Access to Regional Markets (JA FARMS) development project.*

HTH technology has a long history of durable use in the United States, Europe and elsewhere in various climates. Although other greenhouse designs have been constructed over the years in Jamaica, the HTH houses were selected for their suitability, low cost, simple design, field construction characteristics, quick construction, simple maintenance and operations that fit well in the Jamaican topography and climate. HTHs can be easily constructed in any length desired and can be quickly taken down in the case of a pending natural disaster such as a hurricane and re-assembled after the storm.

HOW TO USE THIS MANUAL

This construction manual is intended as a step-by-step guide to construct a High Tunnel House (**HTH**). The information in this manual is based on field fabrication and construction experience. With any experience over time, knowledge is gained on how to improve or adapt the technology to best suit the area's characteristics. While there are variations in the construction process based on site characteristics and knowledge gained, the major construction procedures such as the actual measurements of pipe spacing, how to brace the pipes, measurement of braces, preparation of land, or amount of needed material does not vary.

Experience has already produced modifications in the materials used. For instance, changes have been made in the size of monofilament, pipe size, type of plastic and mesh used. Other modifications will also be made as experience is gained. As in any guidance of this type there will be the need for local modifications based on a variety of factors, such as cost, availability, durability etc. As the methods improve new experience will be gained and shared.

Please note that it is possible to make size variations of the HTH. The pipe can be bent to desired specifications (for example higher or lower arches). Also, two pipes can be joined at the center arc to widen the house. The HTH can be made longer than the 108ft. length or shorter.

MATERIALS NEEDED TO CONSTRUCT A 108 FT HOUSE

Purpose	Description of raw material	Quantity
Ground Stakes (5' cuts)	1 7/8" Fence Tubing- 20' (steel)	36 (need 9 length of steel)
Bows	1 5/8" Fence Tubing- 20' (steel)	18
Top Center Pipe Brace	1 5/8" Fence Tubing- 20' (steel)	6
Side Pipe Brace	1 5/8" Fence Tubing- 20' (steel)	4
Wind Braces	1 5/8" Fence Tubing- 20' (steel)	4
Pipe Straps	1 1/2" pipe straps	54
Door Frames	2x4x10' treated	6
Wood Screws	2 1/2" drywall screws	2
Self-Tapping Screws	1-1/4inch--Box of 100--(need 201 screws)	3
1" PVC Plastic Pipe	1" PVC - 5'	1
Plastic	7 mil 6m x 100m	610
Monofilament	8mi- 6,000 ft roll, using 6060 feet	2
Shade Paint	Latex white paint- gallon	1
Plastic Draw Strings	Bag of 100 plastic ties	1
Duct Tape	Roll of duct tape	1
Spring hinge for door	Spring hinge	2
Min/Max thermometer	Min/Max thermometer	1
Drip Irrigation	Irrigation tape, roll	3
Male adapter	6 male adapters (screws into the tank.) 2 for the lockoff	2
Elbow	1 elbow	1
Head connector (mainline to drip tape)	Head connector	10
Ground Cover/Plastic Mulch (not necessary all the time)	Plastic sheeting	600
Insect Netting for ventilation and for doors	Insect netting treated anti-viral	2 rolls
Doors	2x4x16 wood	10 pieces

LIST OF TOOLS NEEDED

- Power Drill, Bits and Screw Driver
- Hammer and Sledge Hammer (Pile Driver & Compressor*)
- Tape Measure
- Square
- Line Level
- Fork, Spade and Rake
- Hack Saw (Portable Band Saw*)
- Wood Saw
- Knife

- Marker
- String or Twine
- Ladder(s*)
- Portable Electric Power Generator
- Leather Gloves
- “T” Pole for Installing the Plastic and Mesh
- Portable Tiller (Tractor*)

(*PREFERRED TOOLS)

BASIC INFORMATION

The HTH described in this manual is 108 feet long, 16 feet wide, (1,728 sq feet) and 9 feet tall. It uses two (2) rolls of UV treated plastic cover and two (2) roles of mesh or mosquito netting. Planting inside of the greenhouse can take a variety of forms, including: raised beds, pots, potting bags, tables, trays etc. HTHs have proven to produce high quality crops, extend the growing season and decrease the chemical inputs necessary with field crops.

It is important to begin by selecting the correct seeds. Seed varieties used in the greenhouse should be *greenhouse variety* and resistant to as many diseases as possible to make sure to get the best growth, yields and quality.

CONSTRUCTION STEPS

STEP 1: SITE SELECTION FOR HTH TUNNEL HOUSE

Site suitability is very important and makes a major impact on the HTH production yields, operation and maintenance costs. Avoid if possible, high wind areas, low lying areas that flood easily, the base of hills where water might pool or flood, and areas that may have been used for previous cultivation that maybe contaminated by previous improper ground use. The site should be as level as possible and near a good water source, (i.e. tank, well, stream, or pond for irrigating). The site should be secure and accessible for loading and unloading of materials and greenhouse products. (See Appendix 1 for HTH Site Suitability Checklist).

STEP 2: SITE PREPARATION

Land preparation produces the best growing condition. The soil should be analyzed by a soils lab. Based on the soil lab recommendation a cost comparison should be made between the costs of soil conditioners to improve the existing soil versus bringing in replacement soil for the greenhouse. Rocky or very hard soil requires more time to level, cultivate. It also more difficult for driving in the required ground stakes described in STEP 3 (Figure 1).



Figure 1 Site preparation

STEP 3: LAYOUT OF HTH FOUNDATION AND STAKES

ITEMS NEEDED

- 9 1 7/8th 20ft steel pipe cut into 5 ft. lengths
- 36 5ft Foundation Stakes
- Portable Electric Generator
- Power Saw for cutting pipe
- Measuring tape
- 76 in. Measuring Rod (pipe, PVC pipe, stick)
- Square tool
- Line Level
- 2 cords /strings at least 108 ft. in length)
- 4 Corner Pegs (or wood to place at the each corner)
- Pile driver and Compressor
- Marker

CONSTRUCTION STEPS

- The foundation corners of the HTH needs to be squared to the length and width.
- Measure out the length and width dimensions of the HTH. Drive a peg into the ground at each corner. Use the square and cord to mark a straight line for foundation stakes.
- Make sure that the straight lines are at a 90° angle.
- Cut 36, five (5) foot pipes for foundation stakes. With a hammer make a crimp at the bottom end of each stake to make it easier to drive the stake into the ground. (Figure 2).
- Measure and cut a 76 inch measuring rod (Figure 3). The measuring rod measures the space between the foundation stakes. Use the measuring rod to mark off from the inside of the first foundation stake the distance for the placement of the next foundation stake. (Figure 3). There are a total of 36 foundation stakes, 18 stakes on each side.
- Line out the ground stakes on both sides. Tie a line at the top of the first foundation stake to the top of the last foundation stake. Use a line level to level the foundation stakes for both sides.
- Measure and mark 20 inches from the bottom and 6 inches from the top on every ground stake.



Figure 2 Crimping foundation stake point



Figure 3 Foundation stake measuring rod

STEP 4: DRIVING FOUNDATION STAKES IN THE GROUND

ITEMS NEEDED

- Pile driver and compressor (sledge hammer)
- Thick board to protect the top of foundation stake

CONSTRUCTION STEPS

- It is important to protect the top end of the foundation stake from bending or crimping. Cover the top part of the foundation stake with a piece of wood to prevent closing or bending the pipe opening. Drive the foundation stake 20 inches into the ground.
- Drive in all 36 foundation stakes, 18 foundation stakes on each side of the HTH (Figure 4).



Figure 4 Leveling and marking foundation stakes

STEP 5: SELF-TAPPING SCREW FOR FOUNDATION STAKE

ITEMS NEEDED

- Power Drill
- 36 Self-tapping screws

CONSTRUCTION STEPS

- With the foundation stakes now securely in place measure and



Figure 6 Screwing in self-tapping screw



Figure 5 Six inch mark for self-tapping screw

mark 6 inches from the top of the foundation stake for placement of a self-tapping screw. Fasten the self-tapping screw at the 6 inch mark. Repeat the process for the remaining foundation stakes on each side of the HTH (Figures 5 and 6).

- The roof hoops will later be inserted in the foundation stake pipes and rest on the self-tapping screw at the 6 six inch mark.

STEP 6: Hoop Attachment

ITEMS NEEDED

- 18 hoops
- drill and self-tapping screws

CONSTRUCTION STEPS

- To install the roof hoop pipes slip the hoop pipe into the foundation stakes on each side of the HTH so that the hoop pipes are resting firmly 6 inches inside the foundation stake resting on the self-tapping screw from Step 5. Inserting the hoop pipe into the stake requires exerting pressure on the hoop pipe to force it into the foundation stake. Once in place the hoop pipes begin to form the hoop frame. (Figure 7).
- Repeat the hoop pipe insertion procedure into the foundation stakes for all of the 18 hooped pipes (Figure 8).
- While the pressure from the arched pipe will usually be enough to hold the hoop pipes in the stakes, it is recommended to fasten a screw through the stake and the hoop pipe to keep the hoop pipe from slipping out of the stake.



Figure 5 Installing hoop pipes into foundation stakes

STEP 7: MEASURE AND MARK TOP CENTER BRACE

ITEMS NEEDED

- Measuring tape
- Marker

CONSTRUCTION STEPS

- With the entire hoop frame now installed locate, measure and mark the top center of the hoop house on the front and end of the house hoop frame.



Figure 6 Complete hoops in foundation stakes

STEP 8: INSTALL TOP CENTER BRACE PIPE FOR HTH

ITEMS NEEDED

- 6 20 ft. 1 5/8th steel pipes
- Power Drill
- 18 pipe straps
- 60 plus self-tapping screws
- 5 1 inch PVC pipe that is 12 inches in length



Figure 7 Completed center brace pipe

CONSTRUCTION STEPS

- The top center brace pipe is the first brace to be attached to the underneath part of each hoop (Figure 9).
- Start at the front of the house with hoop pipe #1. At the center mark from Step 7 secure a 20 foot center brace pipe with a pipe strap using two (2) self-tapping screws to the underneath center mark of the hoop (Figure 10).
- At the opposite end of the center brace pipe attach it with a pipe strap and two screws. (Figures 9 and 10).
- Each of the 20 foot center brace pipes are joined together and held in place with a piece of 1 inch x 12 inch PVC pipe.
- Slip the PVC pipe 6 inches (half way) into the first installed center brace pipe. At the end of the center brace pipe drill two (2) self-tapping screws into the center brace pipe to secure the PVC pipe in place. Connect the next 20 foot section of center brace pipe to the first one by inserting the PVC pipe inside the second center brace pipe. The two pipes should butt together. Screw second brace pipe into the PVC pipe with two self-tapping screws.
- Secure the remaining 6 center brace pipe 20 foot sections with the pipe straps and PVC connections (Figure 9).
- Fasten with a screw through the pipe strap of the center brace pipe the front and rear hoop pipes. The screw secures the center brace pipe from slipping out of the pipe strap at the front and rear of the hoop pipes.



Figure 8 Installed center brace pipe straps with two self-tapping screws

STEP 9: INSTALL SIDE BRACES TO FRONT AND REAR OF HTH

ITEMS NEEDED

- 4 1 5/8th steel pipe
- 10 Self-tapping screws
- Drill
- Measuring Tape
- Marker

CONSTRUCTION STEPS

- Measure and mark 4 feet 4 inches from the top of the foundation stake to attach the side brace. Measure both front and rear sides of the hoop house.
- Attach the side brace pipe on hoop pipe number two (2) through hoop pipe number five (5) with pipe strap (Figures 11 and 12).
- Attach the other end of the side brace to the 5th hoop pipe (Figures 11 and 12).



Figure 9 Side pipe brace connected to hoops 2 & 5

STEP 10: SIDE BRACES CONTINUED

ITEMS NEEDED

- 8 10 ft 1 5/8th steel pipe lengths (cut 4 20 ft steel pipes in half)
- 20 self-tapping screws
- Drill
- Measuring tape
- Marker

CONSTRUCTION STEPS

- Install four (4) side brace pipes to the front and rear hoop pipes (Figure 11).
- Measure and mark the both sides of the front hoop pipe and rear hoop pipe in 2 places: one at 26 inches measuring from the top of its foundation stake and the second at 78 inches from the top of the same foundation stake.
- Flatten one end of the side brace pipe vertical and flatten the other end horizontal. (Figure 12).
- Attach the side brace pipe at the 26 inch mark of the side hoop (Figures 13 & 14).
- Next, attach the other end of the brace to the side brace with a screw (Figure 14).
- Repeat the procedure at the 52 inch measurement. This will form a diagonal angle. (Figures 11, 14 and 15).



Figure 10 Flattening end of side pipe



Figure 13 Side brace flattened on end for screw connection

- After installing the side brace pipes tamp down sharp edges or burrs. Put duct tape around the area where the two braces meet at the side brace (Figure 16) to protect the plastic from rubbing against the steel braces.

STEP 11: INSTALLING AND TYING THE MONOFILAMENT LINE

ITEMS NEEDED

- Monofilament Line (thick fishing line can be used)
- Marker
- Measuring Tape
- 2 Ladders
- Knife

CONSTRUCTION STEPS

- The hoop pipes provide the major support skeleton of the HTH. Monofilament line (fishing line) is stretched tightly over the exterior of the steel hoops along the length of the HTH to provide added strength and support for the plastic cover to rest on. Monofilament



Figure 17 Monofilament line across top of HTH

line stabilizes the plastic by keeping the plastic tight against the hoop to stop the plastic from buckling or becoming slack during high winds and heavy rain.

- To prevent hand cuts and bruising wear gloves for stretching and tying the monofilament line.
- The monofilament line spacing is closer for the top of the house with larger spacing along the sides as described below (Figures 17 & 18).
- Start from the center of the first hoop pipe (measure from the center highest point on the hoop house) and working outwards on one side of the hoop. Measure six (6) inches from the center brace then mark it. Working away from that first mark, measure



Figure 18 Monofilament clipped to hoop pipes

- another six (6) inches and mark it. Working down the side of the hoop continue measurements and markings for a total of five (5) measurements each six (6) inches apart.
- Moving down the exterior of the hoop from the last (fifth) measurement, space the next four (4) measurements nine (9) inches apart.
- Moving further down the hoop from the last measurement, space the next three (3) measurements 12 inches apart.
- The last two (2) spacings are 18 inches apart.

The bottom most measurement should be approximately 5 inches from the ground.

- Repeat the above measurements and markings for the other side of the HTH.
- Recheck the markings on both sides.
- Monofilament installation works best with three (3) installers; however, it can be installed with as few as one (1) installer. Place two (2) of the installers each on a ladder at the front and end of the hoop house (Figure 19).



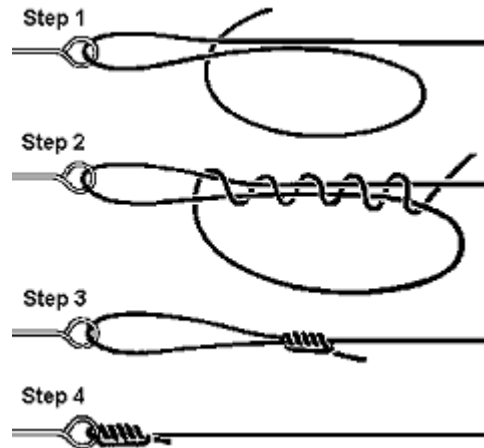
Figure 19 Stretching and tying monofilament

- Starting from the center brace, the first end installer wraps the monofilament twice around the hoop and then ties the monofilament line (Knot Figures 1-4) and hands the line to the middle installer who passes the monofilament along the outside of the hoop house to the opposite end installer. This opposite end installer pulls, wraps, ties and cuts off the excess monofilament.
- The middle installer checks to make sure the lines are on the marks of the hoop pipes and tight without any line slackness.
- The preceding process is repeated for the remainder of the monofilament installation.
- Complete installation includes one (1) mono filament line across the center brace and fourteen (14) monofilament lines on each side of the hoop pipes.

KNOT FIGURES 1-4

- Wrap the line twice around the hoop
- Bring the end of the line towards the hoop, passing it under the doubled part.
- Make five to eight loops or wraps over the double line

- Carry the end back towards the hoop and run it through the opening near the hoop two times
- Pull the knot tightly together to secure it
- Push the knot down the line towards the hoop. It should be touching the hoop.



Knot drawing retrieved from: www.fishingcairns.com.au/page6-1.html

STEP 12: TRENCHING FOR MESH AND PLASTIC COVER

ITEMS NEEDED

- Plastic and Mesh covers
- Measuring tape
- Spade, shovel, fork

CONSTRUCTION STEPS

- Along the entire exterior sides and both exterior ends of the greenhouse dig a 20 inch deep by 20 inch wide trench.
- Pile the dug out dirt along the outside of the trench. The piled dirt is later used to backfill and cover the plastic cover to anchor it to the ground. Figure 20 shows the burying of plastic that will be done in Step 14.
- Use heavy back fill soils with care when filling the trenches to avoid tearing the plastic.
- When digging the trench for the placement of mesh dig the trench about 8 inches deeper and about 4 feet wide or the equal to the width of the mesh.
- Measure 14 feet from the first hoop.
- The mesh will be installed starting at this mark. The trench needs to be dug deeper from 14 inches to 18 inches deep.
- Each side of the plastic should cover approximately 2 feet of the mesh. The plastic should overlap approximately one foot.
- Mesh should be placed approximately every 17 feet. (See Figure 30)



Figure 20 Careful back filling of trench to bury and anchor mesh & plastic cover

STEP 13: MESH INSTALLATION

ITEMS NEEDED

- Mesh rolls
- Shovel
- Measuring Tape
- Knife
- Broom or “T” pole for raising the plastic

CONSTRUCTION STEPS

- The mesh is installed over the hoop frame to provide protected ventilation
- The location and amount of mesh depends on the amount of required protected ventilation. Mesh is placed at measured intervals along the length of the house. Begin by measuring 14 feet from the front of the house and place the mesh at regular intervals.
- The mesh will be placed in the same trench as the plastic cover. Therefore in Step 13 the mesh will be placed in the trench and only partially back filled with soil to hold the mesh in place. (In Step 14 the mesh will be covered with plastic. Both the mesh and plastic will then be buried with the remaining soil).
- Bury the end of the mesh in 6 inches of soil. Pass the remaining mesh over the top of the house to the other side. Make sure that the mesh is placed directly across from each side and line up.
- Stretch and smooth out the mesh so that it is laying flat against the hoop and monofilament.
- Allow for enough mesh to bury in the trench. Cut the mesh.
- Bury the mesh in 6 inches of dirt making sure to keep the mesh pulled tight against the hoop frame on each side. (Figures 21-23)
- Repeat the mesh installation at the remaining measured and marked locations.



Figure 21: The mesh is stretched tight over the HTH



Figure 22: Anchor mesh partially buried in 6 inches of soil



Figure 23: Mesh is installed and buried in the trench

STEP 14: PLASTIC COVER INSTALLATION

ITEMS NEEDED

- 1 roll UV plastic
- Monofilament line
- Device to roll out the plastic (Figures 24 and 25)
- Measuring tape
- “T” bar
- Ladder

CONSTRUCTION STEPS

- Clear the area of any debris that could cut or tear the plastic cover.
- Check the plastic roll for the EXTERIOR side on the plastic. Roll out the plastic with the



Figure 11 Pipe roller placed on two ladders

exterior UV side facing outwards from the hoop pipes.

- Devise a method to roll out the plastic cover. Use one of the straight metal pipes as the roller. Pass the metal pipe through the roll of plastic cover and set the pipe between ladders, concrete blocks, logs etc. off of the ground.(Figures 24 and 25).
- Carefully roll out the plastic. For an 18 foot wide HTH at least 20 feet in of plastic is need. The method is to unroll and pass the plastic from the roller side of the hoop frame to the other side.
- On method for passing the plastic from one side to the other side of the hoop frame is to bunch a end of the plastic cover and tie monofilament line to the end. The line is passed or tossed over, if a small weight is attached such as a rock, to the other side and pulled. When in place on the other side the line is untied. An installer can also stand inside the HTH with a “T” bar, or a blunt stick covered with a cloth or on a ladder to slowly push up on the plastic cover as it is pulled across the hoop frame. The inside installer guides the plastic cover as it passes over the hoop frame.
- Carefully pull the plastic by the end string over the hoop frame avoiding any tears.
- The passed over plastic end is pulled over to the opposite side to be aligned, stretched, partially buried in the trench and cut.
- The first plastic cover section must overlap the front end of the first hoop pipe 50 inches on both sides. This front plastic overlap later attaches to the front door frame in Step 16 (Figures 30 - 33).
- The plastic cover should lay flat against the monofilament and hoop frame (Figure 27).
- Place the plastic end flat into the trench so that extends outside of the trench, partially cover it with soil.
- Line up the next role of plastic and cover the remainder of the HTH frame with plastic. The plastic cover should overlap each preceding section by at least one (1) foot.
- When fully covered re-check and bury each side completely (Figures 28 and 29).



Figure 25 Pipe roller placed on two concrete blocks



Figure 26 Partially buried plastic



Figure 27 Another view of buried plastic



Figure 28 Burying remaining plastic



Figure 29 Plastic completely buried



Figure 30 Plastic overlap front & back to attach to frame

STEP 15: Constructing the DOOR FRAME (ON BOTH ENDS OF THE HOUSE)

ITEMS NEEDED

- 4 2x4x16 pieces of wood
- Power saw or hand saw
- Wood Screws
- Self-Tapping Screws
- Drill
- Measuring Tape
- Marker
- Level
- Square

CONSTRUCTION STEPS

- Make the door frames with two (2) 8 foot side door frames.
- Measure and mark 40 inches from each side of the front hoop pipe to the middle of the house.
- Dig two (2) 20 inch deep holes at both of these marks.
- Bury the door frame posts into the holes. Straighten and level the door frame posts.
- Measure and cut the top door frame. The finished door frame will be approximately 9 feet 4 inches wide.
- Cut each side on a bevel to match the curve of the hoop pipe (Figure 31).
- Place the top door frame on the side door frames and attach with screws.
- Flatten two (2) pipe straps on one end. Use the flattened pipe strap to screw to the top 2x4 and the hoop pipe. The flattened end of the pipe strap should face outside.
- Measure and cut two (2) 18 inch 2x4 braces on an angle to fit the door frame (Figure 32).



Figure 31Top, side and angled door brace frame

STEP 16: SECURE PLASTIC TO DOOR FRAME

ITEMS NEEDED

- 4 10 inch by 1 ½ inch wide strips
- Drill
- Hammer
- Wood screws and self-tapping screws
-

CONSTRUCTION STEPS

- Cut 4 wood strips 1 ½ inches wide by 10 inches long.
- Bury the front plastic in the trench on both sides.
- Wrap the plastic tightly around the door frame. Nail the wood strips over the outside of the plastic cover to the door frame (Figures 32 and 33).
- Wrap the top plastic cover over the top of the door frame and angle brace. Nail the wood strips over the outside of the plastic cover to the door frame (Figures 32 and 33).



Figure 32 Exterior plastic secured to door frame

STEP 17: CLOSING HTH REAR WITH MESH

ITEMS NEEDED

- Mesh
- 3 2x4x16 wood pieces
- Drill
- Self-tapping screws
- Saw
- Measuring Tape
- Marker
- Wood strips
- Shovel and/or fork



Figure 33 Interior plastic secured to door frame

CONSTRUCTION STEPS

- Close the HTH rear with mesh (or plastic) to protect from insects.
- Measure, cut, level and attach with straps and screws to the inside of the rear hoop pipe a boxed frame with 2x4s.
- Wrap the mesh tightly around the rear frame.
- Attach the mesh to the wood frame with wood strips.
- Bury the bottom of the mesh in the trench with soil.

STEP 18: TWO TYPES OF DOORS

ITEMS NEEDED

- 2x4x16 pieces of wood
- Hammer
- Wood nails
- Wood strips
- Plastic to cover top of door
- Drill
- Measuring tape
- Square
- Marker
- Level

CONSTRUCTION STEPS

- The door(s) can be installed at either or both ends of the HTH.
- Select the door type, height and width dimensions to allow for easy entrance and exit with equipment, supplies and produce.
- Use the door frame from Step 15.
- One simple door is a center opening, left-right hung double door system that is installed with a door frame and hinges flush with the hoop pipe frame constructed in Step 15. Measure, cut and screw together two (2) matching door frames. Stretch and attach mesh to the finished door frames with wood strips. Hinge one door on the left and the other on the right and attach the two (2) doors to the exterior sides of the hoop pipe door frame. The doors open out.
- Another door is the two (2) door passageway or vestibule in Figures 34 and 35. The passageway is designed to reduce insect infestation when entering and exiting the HTH. Construct a passageway frame.
- Attach the passageway frame to the hoop pipe with straps and screws. Attach plastic to the passageway roof and mesh to the three exterior sides.
- Measure, cut, make and screw together matching exterior and interior doors. Cover the exterior and interior doors with mesh and attach the mesh wood strips.
- The doors can be hinged to swing out or in. An inward opening hinged exterior door is protected from wind damage when open but requires a larger passageway size to accommodate the door. The doors in Figure 34 are designed to open inwards into the passageway. The depth of the passageway must be large enough to fully open the doors to avoid only partial opening of the doors or the having the doors hit each other. The doors should be hinged on opposite sides of the door frames, one hinged left and the other hinged right.



Figure 34 Entrance door protective enclosure