High Tunnel Design, Site Development, and Construction

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Figure 1. Common high tunnel terminology.

Experienced specialty plant growers can increase the quality of their products and the duration of their marketing of high-value crops through the use of high tunnels. High tunnels give growers the opportunity to plant earlier and include more sequential planting dates. This can result in early-season, high-dollar returns and the ability to offer their products for longer periods. High tunnels also provide environmental protection, which helps reduce blemishes and discoloration, improving visual appeal. For successful high tunnel crop production, decisions and actions before planting the first crop include choosing a structural design to meet specific needs, identifying the best site for locating the structure, initial soil preparation, and the method of construction.

High Tunnel Design

Structural Components

Before purchasing a high tunnel, it is critical to know what parts are used in the structure, how to decide on the size and shape of the unit, and what options will be needed for specific production methods.

High tunnels can vary in size and shape, but all use similar parts, materials, and construction methods. A high tunnel is a series of hoops that are held in position with continuous lengths of supporting structural members (purlins and girts) and end walls with accessible doors. The exterior covering is typically a greenhouse-grade polyethylene plastic that can either remain on the structure year-round or be removed during

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Figure 2. Common high tunnel profile designs include the hoop (*left*), raised hoop (*center*), and peaked hoop (*right*).

the heat of summer. The hoop-style high tunnel in *Figure 1* identifies key parts labeled with commonly used terminology.

The Hoop

A series of hoops or bows make up the primary skeletal structure of high tunnels. These provide support for the outer covering and maintain structural integrity against environmental forces. The spacing of the hoops can vary, depending on the desired structural strength. Hoops are most commonly spaced at 4, 5, or 6 feet. Narrower hoop spacing provides more support for the polyethylene covering, requires the use of smaller diameter metals, and allows easier shedding of rain and snow. However, structure cost increases with more hoops, and there is a potential for increased structural shading. If wider hoop spacing is used, larger outside diameter (OD) metals are needed for structural strength against wind, rain, and snow loads.

End Walls

The size and type of end walls are designed to meet accessibility requirements for people and equipment. Most suppliers carry a variety of end wall framing packages, from simple pass-through doors to framing with larger openings that allow for the use of rototillers and tractors. It is important to remember to include a small door for access if the high tunnel will be used during the coldest part of the year since large openings will greatly reduce the ability to keep the inside temperature warm. End walls can be custom framed using lumber or metal piping if the polyethylene can be securely fastened to prevent air leakage or being blown in by high winds. Polyethylene zip entry end walls are an available option from some high tunnel suppliers, but these are not recommended for High Plains growers due to the risk of premature failure of the closure system from strong winds.

Purlins and Girts

Purlins run horizontally from end to end of the high tunnel, maintaining hoop spacing and increasing structural strength. Typical structures have three to five purlins, spaced at 4 to 8 feet apart. Girts are stronger than purlins and are generally manufactured of square tube or roll form metals. Girts provide greater structural support for polyethylene retaining systems (poly-locks), roll-up wall components, or other equipment. They are installed in positions similar to purlins to maintain hoop spacing. If the supplier provides only one ridge purlin for a particular type of high tunnel, additional purlins or wall girts must be added to prevent structural failure.

Wind Bracing

Overall structural integrity depends on the number of angular wind braces positioned within the structure. At a minimum, these braces should be positioned between the end hoops and the baseboard at each corner. Additional angular bracing can be installed from the ridge and roof purlins and connected to the end wall framing to increase structural strength. This is especially important in high wind locations.

High Tunnel Profiles

High tunnel suppliers offer a variety of profile designs (*Figure 2*). Growers should select the optimum high tunnel profile based on its intended use, the desired durability, and budget. The following paragraphs summarize each profile and its specific features of interest to the grower.

Hoop or Half-Round Style

This is the most common high tunnel profile since it requires the smallest number of structural members and can be easily manufactured and built by individuals with little construction experience. The support hoops of the half-round profile have a smooth, gradual bend that limits the number of stress points on the plastic covering. The hoops bend from the ground on one side of the structure to the ground on the other side to form a continuous arch. This design may limit access or standing room along the sidewalls.

Raised Hoop

The raised hoop design is a modified hoop structure with sidewalls created by extending the vertical ground posts to the desired height (typically 36 to 60 inches). The straight sidewalls allow for greater accessibility along the wall and provide more usable growing space; however, raised hoop structures are taller than typical hoop profiles. The raised hoop design is preferred when using roll-up sidewalls because it prevents rainwater from draining directly from the roof into the growing beds, which can negatively affect plant or flower quality.

Peaked Hoop

These structures are constructed by adding a bend at the apex, or top point, of the hoop or bow to create a distinct ridge. This ridge provides additional strength against cross-winds and creates a steeper roof pitch that sheds rain and snow more quickly. Peaked hoop structures typically have distinct roof and sidewall surfaces that are divided by a wall girt or eave board. This allows for the easy integration of roll-up or drop-down sidewalls for natural ventilation.

High Tunnel Size

Suppliers of high tunnels offer structures in various widths, lengths, and heights, all designed for the efficient use of industry standard-sized polyethylene coverings and lengths of metal tubing.

Overall Dimensions

Structures appropriate for growing home garden crops may be as small as 8 feet wide by 10 feet long. Commercial production tunnels can be 20 to 30 feet wide and any length. Growers often use high tunnels that are 48 feet, 96 feet, or 144 feet long so that standard 100-foot or 150-foot lengths of polyethylene can be used efficiently. If a longer structure is needed, polyethylene splices are installed to connect multiple lengths of polyethylene. It is important to remember that the larger the polyethylene sheet, the greater the difficulty of installation, and the greater the weight of the covering on the structure.

Determining High Tunnel Width

High tunnel width is a grower's personal decision based on the desired interior layout and placement of growing beds, walkways, and support trellises, and the type of equipment that will be used inside the structure. The only physical limitation on the area being covered is the size of the available site. The most affordable option is to purchase "off the shelf" high tunnel packages as these often use standard-sized steel or aluminum and polyethylene sheets that result in the most floor space at the lowest per foot cost.

A typical half-round high tunnel is usually half as tall as its width. For example, a tunnel 20 feet wide will be approximately 10 feet high at the center ridge. If the structure is narrower than 12 feet, ground post extensions may be required to allow for more accessible headroom and more usable space next to the sidewalls. Peaked hoop designs have the widest amount of usable floor space, but overall height decreases as the structure is widened, which may result in low headroom space near the sidewalls. Wider tunnels have a flatter roof pitch that may negatively affect the shedding of rain and snow, potentially leading to structural collapse.

Exterior Coverings

The roof and sidewalls of high tunnels are typically covered with polyethylene (poly) plastic. Greenhouse-grade, 6-mil ultraviolet light (UV) protected poly should be used. Do not use construction grade poly found at construction supply or hardware stores. The UV polymer resins in greenhouse-grade plastics increase the longevity of the covering to more than four years when securely fastened to the structure. Poly

Figure 3. Twin wall (*left*) and corrugated polycarbonate panels (*right*) provide options for walls.

Figure 4. A spring lock polyethylene retention system holds polyethylene in place.

coverings containing additional infrared or anti-condensate resins are available at a higher cost. These plastics can improve crop productivity by enhancing daytime light quality, preventing heat loss at night, and reducing the incidence of diseases spread by condensate drip.

End walls are tall, flat surfaces that are exposed to high winds, heavy rains, and hail. They tend to receive excessive wear due to movement through the door openings. End walls can be covered with poly sheeting, but it is preferable to use a more durable rigid product, such as corrugated or twin-walled polycarbonate sheeting (*Figure 3*). These products will be more expensive than poly, but light quality will remain high for 10 years or more and they will not deteriorate as quickly.

Polyethylene Retention

Historically, poly plastics were held in place by fastening wood lath or batten tape over the perimeter edges of the plastic sheet to the baseboard. Although inexpensive and functional, these methods did not hold as securely as a polyethylene lock system (poly-lock) and were time-consuming to install. Polyethylene locking systems consist of two pieces, a receiver base and a locking member. The most affordable system uses an aluminum "C" profile receiving base that has a bent wire (known as spring lock or wiggle wire) locking member inserted into it over the poly sheet (*Figure 4*). This provides a strong, reusable, long-lasting retainer for plastic coverings and can also be used to hold shading fabrics or insect netting. There are other types of poly-locking systems available from suppliers that function in a similar way.

Figure 5. Roll-up sidewall components provide options for improved interior temperature management. Note overlapping wall blanks at both ends of the roll-up wall to prevent cold air infiltration.

Tunnels with Opening Side Walls

If only the end wall doors can be opened, air movement will be limited and excessive heat can build up in the high tunnel. Installing roll-up or drop-down sidewalls allows poly to be incrementally opened as much as 4 to 6 feet on each side of the structure. This ability to create more venting capability lowers the temperature in the high tunnel during periods of high sunlight or excessive heat.

Roll-up walls (*Figure 5*) use a metal tube (roller tube) that runs the length of the sidewall with the bottom edge of the poly fastened to it. A hand crank is attached to the end of the tube, allowing the poly to be rolled up to the eave of the high tunnel wall. There are roll-up window vent hand cranks available with a locking mechanism (*Figure 6*) that allow the wall to be opened to various dimensions to regulate the

Figure 6. Hand crank roll-up window vent machine

Figure 7. Drop down sidewalls (*above and adjacent*) are preferred since ventilation occurs above the plants rather than near the ground, which can slow plant growth and increase the potential for cold injury.

amount of air let in. This is the simplest design for sidewall ventilation; however, the opening near the ground allows infiltration of weed seeds, easy access for rodents, and herbicide drift. Early season venting will make the ground near the walls very cold.

Drop-down sides are an alternative to roll-up walls (*Figure 7*). These are more complicated to install but are best for modulating air temperatures during early and late season production. A leading edge tube with the wall poly attached to the top of it runs the length of the high tunnel sidewall in a drop-down sidewall system. A series of cables are attached to the leading edge and connected to a main cable that is operated by a winch at one end of the high tunnel. As the winch takes in the main cable, the leading edge cables are pulled up toward the eave, closing the sidewall. If the winch is retracted, the sidewall drops down from the eave to any desired opening height.

Construction Materials

High tunnel manufacturers offer structures of comparable size in a wide price range, requiring buyers to carefully evaluate the design and which components are included in the package. Structure durability is greatly affected by the quality and grade of the materials used. Most structures are built using steel tubing that is available in varying diameters and metal thicknesses. Greenhouse-grade tubing is typically galvanized and has an additional rust prevention coating. Tubing is available in a variety of outside dimensions (OD), with tube sizes of 1.315 inches, 1.66 inches, 1.90 inches, 2.197 inches, and 2.375 inches OD being the most common. The smaller sizes (1.315 inches and 1.66 inches) are often used for purlins and bracing. Larger diameter tubing is used for bows, ground posts, and sidewalls.

High tunnels with additional features, such as sidewalls that open and rigid panel coverings, may include roll-formed metal components that make assembly more efficient. To make roll-formed metal, flat sheets of aluminum or galvanized steel are cold-formed through a roll-form die to create custom structural profiles. These strong framing members are easily attached to tubular hoops using pipe clamps or self-tapping screws.

Less costly packages or do-it-yourself designs may require the use of locally available materials. Dimensional lumber is affordable and easy to use. Treated lumber is not recommended because it can accelerate degradation of the polyethylene, potentially affect plant growth, and prevent organic production certification. Other options include PVC (polyvinyl chloride), solid plastic products, and byproducts of blended plastic and wood. PVC products have limited use for high tunnels due to their limited strength and narrow temperature stability range. Solid plastic and composite products are easy to use and resistant to weather deterioration, but have varied construction capabilities. Before using wood alternative products, evaluate their application according to manufacturers' recommended uses and guidelines.

Figure 8. This new high tunnel site provides well-drained and productive soils, full sun exposure, and protection from high winds.

Site Development

Assessing and Selecting a Location

A productive high tunnel site should be fairly level with deep, well-drained productive soils, good air movement, and unobstructed sunlight (*Figure 8*). Plant health and productivity are directly influenced by both environmental and soil conditions. High tunnels allow for the controlling of air temperature and movement, but any soil improvements cannot be done very quickly. For this reason it is critical to consider the soil first.

Fields currently in production typically have soils that are less compacted and more productive with fewer weeds than newly cultivated fields. Silty loam, silty clay loam, or sandy loams are preferred soil textures for high tunnel production. In upland locations, different soil depths and conditions may exist in close proximity to one another, so it is important to evaluate several areas within the proposed site. Soils with higher clay content present more production challenges but are usable if carefully managed to avoid compaction or excessively wet conditions that limit air exchange. A soil test to evaluate the soil chemistry and fertility is recommended. Additionally, avoid sites previously treated with insecticides or herbicides since these may cause production problems inside a high tunnel.

Topography

Optimal high tunnel sites are slightly elevated, with a 1 percent to 2 percent grade. Avoid moderate to steep locations; these may have shallow soils with poor fertility due to erosion. Cold air may collect or pool in low-lying sites, which may increase the incidence of late spring or early fall frosts in these areas. Evaluate each potential high tunnel site for both soil water infiltration and excessive water runoff. Prime locations have deep, fertile, and well-drained soils, and little potential for cold air pooling. If a grower decides to use a site that is not optimal, careful structural planning and additional site preparation will be required.

Sun, Wind, and Temperature

It is important to choose a site with unobstructed sunlight, gradually modulating temperatures, and good air movement. If vegetation exists in the area around the high tunnel, it can help create an optimal microenvironment for plant growth. Distant trees effectively reduce wind speeds near high tunnels but allow for good air movement within the structure. Shrub rows or ornamental grasses can be planted near high tunnels to create a microclimate and help direct snow deposits away from the structure. Ponds and lakes will “bank” mean seasonal temperatures and modulate daily temperatures. This will keep summer daytime temperatures cooler and prevent early fall frosts; however, spring warm-up can be slower. Production areas near grasslands or forested sites will have cooler environments with fewer temperature extremes than locations adjacent to neighboring fields or suburban developments.

Adjacent Land Uses

Adjacent land uses may affect the grower’s ability to manage the high tunnel environment, crop productivity, plant quality, or organic certification. Traditional agricultural production fields present a challenge to successful high tunnel production. Temperatures and wind speeds vary as crops mature and are harvested. Deleterious insect populations can quickly increase as a result of neighboring crop maturation or production activities. Windborne dust and debris can

Figure 9. Creating a level site through cut and fill excavation will result in compacted soils that are unlikely to be suitable for in-ground plant production.

affect specialty crop quality, as can the increased potential for agricultural chemical drift that can result in plant injury or death. Nearby animal holding areas, such as pastures and feedlots, increase the risk for contamination of edible fruits and vegetables due to animal waste pollution.

High tunnels near expanding urban or suburban areas or major transportation corridors can be affected by air and storm water pollutants, increased heat and runoff from pavement, and changes in topography associated with development.

Neighbors

A high tunnel can affect neighboring property in either a positive or negative way. What may be of interest and excitement to a grower may not be visually appealing or may be a safety concern to a neighbor. Show respect to neighbors by carefully locating and constructing an aesthetically pleasing, high-quality structure. Neighbors have the ability to positively or negatively affect the business.

Tunnel Positioning

A level site is preferable for unrestricted positioning of a high tunnel; however, this is not always possible. Although an excavation contractor can be hired to create a level site, this should be avoided by growers planning on in-ground plant production due to the amount of bed development required to make productive soils and the probability for excessive subsurface compaction (*Figure 9*).

On a moderately hilly site, a high tunnel should be placed parallel to the grade, similar to contour farming. By working with the slope, high tunnel installation, management, and plant production activities will be less laborious; however, the production environment may not be optimal. Drainage ditches must be created on the side of the tunnel facing the upward slope to divert storm water runoff from flowing through the tunnel.

Direction of the Sun

Warming the growing beds is critical for early season production. This is accomplished by solar radiation being absorbed by the soil. Any obstruction of light or shading will reduce solar radiation absorption. Orienting the structure north-south will allow the sun's energy to reach the maximum floor area. This orientation also allows light to penetrate the foliage of crops of different heights with a minimal amount of plant shading (*Figure 10*).

Many publications suggest that regions north of the 40th parallel should position a high tunnel in an east-west direction. This could allow more sunlight to penetrate the tunnel during the winter when the sun angle is low, but consideration must be given to shading that might result from growing taller crops.

Wind

It is important to position a high tunnel to take advantage of prevailing winds. The goal is to provide good ventilation inside the structure without creating a large wind block. The large expanse of polyethylene covering can easily turn into a large sail that can lift the structure out of the ground. By positioning the structure with the narrowest side (the end wall) into the prevailing wind, less resistance will occur. This orientation also limits the amount of snow that can accumulate on the leeward or opposing side of a high tunnel, reducing the potential for structure collapse.

Because high tunnels are temporary structures that typically use lighter gauge metals and fewer structural components than permanent structures, sites with high winds may require the use of heavier grade metal, installation of more

Figure 10. By orientating the long dimension of a high tunnel in a north-south direction, sunlight is distributed more uniformly to plants.

Figure 11. Cross bracing was installed in the peak of this high tunnel to stabilize the structure during high winds, heavy rains, and snowfall.

structural hoops (or bows), and/or increasing the amount of wind bracing (*Figure 11*).

Soil Preparation

The best time to do major improvements to the growing bed is prior to construction of the high tunnel. Larger equipment may be used for deep tillage in preparation of the growing bed with less chance of damaging the structure. Once the site is prepared, limit the amount of equipment and foot traffic on the site so that only light tillage is required prior to planting.

Locations Previously in Production

The productivity of an existing field will be known, but improvements should be considered prior to installing a high tunnel over any existing site. A deep ripping of the soil will enhance aeration and break up any hardpans that may have developed over time. Incorporation of composted plant material or animal manure through surface tillage improves organic matter content. Improved soil conditions will encourage microbial activity and beneficial organisms, contributing to better breakdown of compost and increased fertility.

New Locations

If a new site has been selected, development of the growing beds should begin the season prior to production. Prepare untilled soils by clearing the existing vegetation, using mechanical removal if possible, to avoid contamination by herbicides. The site should then be deeply tilled and rocks and debris removed before doing the final surface tilling. Use a soil ripper for deep tillage and avoid plowing to prevent a hardpan from developing in the root zone. Cultivate compost or organic matter into the upper 6 to 8 inches for improved soil structure and fertility. Compost is often available at local recycling sites. Rotted alfalfa bales and composted manure from barnyards can be good soil amendments if the source is known.

High Tunnel Construction

Process

High tunnels that are well constructed will give many years of use with minimal maintenance. The following summary of high tunnel assembly provides essential background construction information for people who want to build their own high tunnel.

Plan

Prior to the purchase and construction of a high tunnel, visit the local building code governing authority to understand the legal requirements for a high tunnel and its placement on the property. The agency or department responsible will be able to provide guidance in selection of a high tunnel that meets building codes in the area.

Figure 12. Plan for assistance with unloading the high tunnel components upon delivery.

Order Materials

Growers should search for various suppliers and identify the most suitable structure to meet their needs. Carefully evaluate each structure for the amount of pre-engineering of the structural components and the level of customer support provided by the supplier. Determine whether construction will be possible by following a clear set of instructions or whether the installer will need to custom fit all the components at the site. Contact the supplier regarding the lead time required between ordering and delivery. Some companies will have structures ready for shipping while other companies may only manufacture to order. Once the order has been placed, complete the initial site preparation and structure layout.

Receipt of Materials

Plan ahead for receipt of the materials being shipped. Due to the size and number of components, the high tunnel should be shipped directly to the construction site. While a forklift is useful for unloading the high tunnel parts, it is not absolutely necessary if enough helpers are available (*Figure 12*). Verify that the shipment is complete and parts have not been lost or damaged.

Sort Materials

Identify and sort all parts prior to construction. Match the location where each part will be installed with the manufacturer's instructions and construction plans. Install each component as directed to ensure the safety and durability of the structure. Many suppliers pre-size and predrill various components and also note in the instructions which parts need to be sized to fit properly. If cutting is required, verify the location of each cut before making it.

Structure Construction

Read and completely understand the manufacturer's instructions prior to beginning construction. Pre-engineered structures are designed to withstand extreme environmental conditions when installed correctly. Construction can be accomplished with a few common and specific tools.

The following list will suffice for building most high tunnel structures:

Tape measure—essential for accuracy of ground stake and hoop placement

String line—useful for positioning straight sidewalls, purlins, and hip boards

Wooden stakes—to set straight string lines and mark ground stake placement

Auger—only needed if using concrete piers for support of ground stakes

Sledge hammer—used for driving ground stakes directly into the soil

Cordless or electric drill—for drilling holes for bolts and installing screws

Drill bits—appropriate sizes for installation of bolts or other hardware

Screw hex set—appropriate sizes for inserting self-tapping screws using a cordless drill

String level—used to create a level structure

Carpenter's level—used to create perpendicular walls

Wrenches or socket set—for installation of hardware

Ladder—for installation of purlins and end walls

Level work pad—essential for constructing multiple piece bows

Labor Assistance

The initial layout of a high tunnel can be completed by an individual, but additional help will be needed for construction. Helpers must be physically able to lift and carry components and have previous experience using tools. A team of two or three people will be needed to lift the high tunnel hoops into position and will speed up the process for fastening supporting components and hardware. An assistant can hand tools, supplies, and parts to the person on the ladder installing purlins and end walls. Several people will be needed to help install the polyethylene covering.

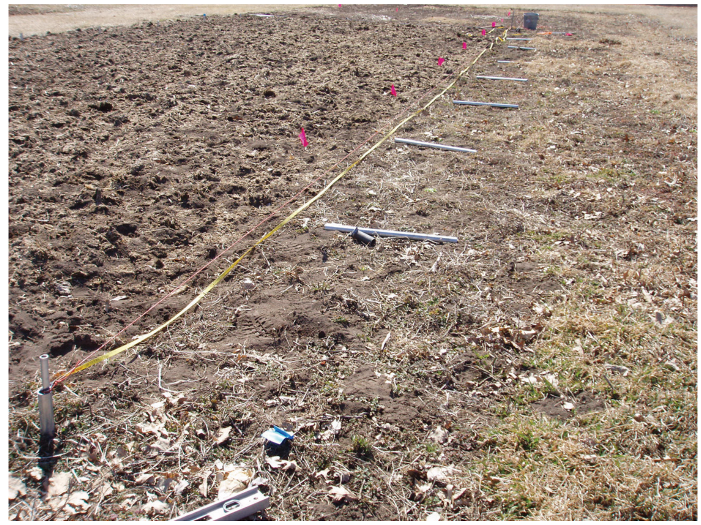

Figure 13. Use of a string line and marking flags to identify ground post locations.

Structure Layout

Layout accuracy is critical for ease of construction, application of coverings, and operation of high tunnel equipment. A string line and corner stakes will be needed to exactly place and square the corners of the structure. To maintain trueness of the sidewalls, measure along the string line and identify ground post locations with flags, marking paint, or stakes (*Figure 13*).

Set the Ground Posts

High tunnels are generally classified as temporary structures, which, according to many building codes, will allow ground posts to be directly inserted into the soil. Verify this with the local governing agency. Ground posts are tubular steel sections that are driven into the ground using a post driver or sledge hammer, or pressed directly into the soil with the bucket of a heavy tractor. The use of a ground post driver cap will prevent post distortion during installation. If the tops of the ground posts are damaged during installation, all posts will need to be cut off uniformly, horizontal to the soil surface.

If pier installation is desired or required by building code, all ground post locations need holes that are drilled using a screw auger at the recommended depth (*Figure 14*). Remove loose soil at the bottom of the holes. Install a bolt through the ground post that will be embedded in the con-

Figure 14. To create a pier foundation for the hoops, holes are drilled into the soil and filled with concrete around the ground posts.

Figure 15. Assembled hoops located near ground posts ready to be tilted into position.

crete to prevent the post from lifting after the concrete has set. Re-establish string lines after drilling the holes so ground posts may be inserted into the poured concrete in straight lines and at a level height.

Frame Erection

Bows will be shipped as multiple-piece units requiring assembly on-site. Assemble the bow sections on a level surface near the construction site so they will be square and true upon completion. Carefully position each completed bow near its ground stake position without bending the unit (*Figure 15*). Any distortion in the bows will cause difficulty in the installation of precut and predrilled components.

Erect the first two or three bows by tilting them upright into position. Fasten the bows to the ground stakes using bolts or self-tapping screws, as recommended by the supplier. Next, install the ridge piece (or ridge purlin) and any additional purlins according to the manufacturer's instructions. Square the structure so it is perpendicular to the ground and maintain this position by installing the diagonal wind braces at the first two end wall corners.

Following the initially erected bow unit, the remaining bows will be systematically tilted upright into position and fastened to the ridge and purlins, maintaining a true structure. Once the final bow is positioned, install the remaining angled wind bracing.

End Walls and Baseboards

Pre-engineered complete high tunnel structures include metal end wall framing components, baseboards and/or roll-up walls with skirts, and swinging or sliding entry doors. By following the manufacturer's instructions, installation of these components should be easily completed as long as the structure was squarely positioned and constructed.

High tunnel structures that were not purchased as a complete unit may require the owner to buy local materials to finish the structure. Lumber will need to be purchased locally for end walls and baseboards. Carefully consider the use of treated versus non-treated lumber. If the wood will come in contact with the soil, treated lumber is commonly used;

Figure 16. Wood baseboards have been installed in a new high tunnel.

however, the use of treated lumber might affect organic crop certification. The grower should contact the organic farmer certification program to learn which lumber and wood treatment products are acceptable.

Wood baseboards should be installed to provide a barrier between the high tunnel growing beds and the outdoors (*Figure 16*). If roll-up walls are used, the baseboard creates a sill for the roll tube to close on. Without a baseboard, cold air can easily pass under the roll-up wall, and rodents and pests can more easily enter the structure. Baseboards set on top of the ground provide little insulation from cold temperature conduction through the soil from outside to inside the structure during winter and early spring. An additional option is to install a construction foam barrier (¾ inch to 1 ½ inches thick) behind the baseboard and bury it a minimum of 16 inches, which improves insulation.

Entries and Doors

Entries are typically designed based on personal preference and accessibility requirements needed for equipment to be used inside the high tunnel. Doors can be constructed using lumber framework covered with polyethylene film sheeting or rigid panels. Doors may be hung using rolling door glides, similar to a barn door, or heavy-duty gate hinges. The entry method selected should close tight enough to prevent wind leakage into the high tunnel. For the Great Plains region, end wall curtains with zipper closure systems are not recommended as high winds will cause them to fail. Sliding door entry systems work best since they can be opened incrementally, require minimal opening space, and remain unobstructed if snow accumulates against them.

Installation of a Polyethylene Roof Covering

Polyethylene locking systems are the most effective method of holding plastic sheeting snugly on the structure. A tight covering prevents excessive movement and flapping that can quickly weaken the plastic. Polyethylene plastic expands when it is hot and contracts when it is cooled. For this reason, it is best to install the polyethylene on a very warm, calm day. In the Great Plains, winds often calm down in late afternoon and early evening.

Before installing polyethylene, distribute the locking pieces around the structure within reach of the lock base channel. Have tools available to install locks and place step ladder(s) inside the high tunnel to assist positioning of the sheet plastic. There are two methods for positioning polyethylene sheeting over the high tunnel structure.

Method 1

Polyethylene is gusseted (folded) in such a way that it can unfold easily from the peak of the structure. The polyethylene may be positioned at one end of the high tunnel with a poly-locking extrusion temporarily installed to hold the starting end of the poly on the center bottom layer of the gusset. The poly is then unrolled down the ridge of the high tunnel to the opposite end. The bottom layer of the poly gusset is then temporarily retained with a locking extrusion on this end. The top gusset fold of the polyethylene should easily pull down to the baseboard or hip boards where the remaining poly-locking extrusions will be installed.

Method 2

The second method is less physically challenging than the first option but requires more labor assistance and has a higher potential for damaging the polyethylene. For this method, the polyethylene is rolled out on the ground adjacent to the long side of the high tunnel. Using clothesline rope or plastic twine, several pieces (a minimum of four, or more, depending on the length of the high tunnel) are thrown over the high tunnel framing. For each rope location, a tennis ball (or newspaper page wadded into a ball) is placed roughly 6 inches in on the leading edge of the top gusset layer of the polyethylene and wrapped around the ball. It is then tied with the rope, firmly holding the polyethylene. Enough help is needed to pull each rope in unison to gradually pull the plastic over the structure. An additional person should be assigned the task of helping the plastic separate from the gusseted fold and to release any snags that might occur as the plastic is pulled over the structure. The ropes are then untied and the polyethylene is positioned squarely so the poly-locking extrusions can be installed.

Figure 17. Positioning of polyethylene is simply done by aligning gusset creases with wall purlins.

Securing Polyethylene Covering

For best fit of the covering, the polyethylene should be positioned squarely over the structure with few obvious wrin-

Figure 18. Locations of end bow and sidewall poly-locks.

kles. To ensure correct positioning, visually line up a gusset crease with a purlin or ridge piece (*Figure 17*). By temporarily locking the polyethylene on one end bow peak, the poly can be pulled from the opposite end bow to pull out any creases or overlapping poly on the ridge.

Final locking of the polyethylene should be done in the following order:

Install locks on end bow “A” (*Figure 18*).

Pull poly away from end bow “A” toward end bow “B” and lock in position.

Install locks on side wall “1” (leave any small creases in position and do not pull to one end).

Pull poly away from side wall “1” toward side wall “2”, then install remaining locks (leaving small creases in position).

If the polyethylene was installed on a warm day, the plastic will tighten as the days cool. By doing this in the summer, an extremely taut covering will result in the fall when the weather cools, and small creases will disappear.

Sidewall Venting

Roll-up or drop-down walls are options on high tunnels that increase air movement within the structure. If installing walls that open, the hip or wall girt these are mounted on must be parallel to the ground with the height of the opening equal on both ends of the structure. Wall blank panels at least 18 inches wide should be used on end bows to overlap the roll-up wall ends (*Figure 5*) and prevent cold air infiltration. Ropes should be installed outside the roll-up or drop-down walls from the baseboard to the eave or hip purlin to prevent “blowout” of the wall covering (*Figure 19*). Inexpensive hand driven roll-up machines are available to allow for variable positioning of the roll-up wall. Drop-down walls are much more complex to install and require several cables, pulleys, and clamps to operate.

Summary

Specialty crop growers and hobby growers using high tunnels are rewarded with more and better-quality harvests. Careful planning, site preparation, and the use of quality components and structure construction methods will ensure greatest success with a high tunnel investment.

Consider the crops to be grown and personal production practices when evaluating potential high tunnel sites. Select gently sloping locations with deep fertile soils and properly prepare them prior to tunnel construction. Specific location conditions, such as available sunlight, prevailing winds, neighboring land uses, and governing regulations, will impact the success of a high tunnel.

Understand high tunnel design, components, and options when selecting the structure for purchase. Before building a high tunnel get approvals from governing authorities on structural requirements and siting of the unit on the property. With careful planning, preparation, and coordination of labor, a high tunnel can be erected with minimal construction skills.

Figure 19. Roll-up window vent with “W” rope lacing to prevent blowout of sidewalls in high winds.