



Movable High Tunnels: Opportunities and Challenges for Producers

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Introduction

Interest in season extension and high tunnels has grown tremendously in the last decade. High tunnels are appealing for the advantages they bring to early and late production. They can also help to control some pest issues and improve quality. The growth in high tunnels is also partially attributable to support from the USDA-Natural Resource Conservation Service (NRCS) Environmental Quality Incentives Program. At the time of this writing, in Kentucky alone the NRCS has funded the construction of over 1,100 high tunnels through the High Tunnel System Initiative, with more approved and awaiting construction. While high tunnels can be a helpful tool for vegetable growers looking to extend the season or improve crop quality, they also come with their own set of challenges. The purpose of this publication is to describe the opportunities and challenges of movable high tunnel production, with practical examples and experiences from research and commercial farm environments.

Why a movable tunnel?

One of the primary reasons growers may look to movable tunnels is to minimize some of the soil health problems that may occur after a few years of intensive high tunnel production, such as the build-up of fertilizer- and compost-based salts in their soils. These salts are charged particles in soil, typically applied for crop fertility in the form of commercial fertilizers, composts, and manures. In open field production, rainfall helps to leach



An overhead view of the movable tunnels at the UK High Tunnel Research Facility. Each tunnel can be moved to three different positions allowing lots of flexibility in rotations.

Photo: Google Earth

nutrients from the soil and pushes salts from fertilizers and other inputs below the rooting zone of the plant. In high tunnels, where rainfall is excluded, these salts can build up in soils and remain in the plant root zone. These salts include positively charged cations, such as sodium (Na^+), potassium (K^+), calcium (Ca^{++}) and magnesium (Mg^{++}), as well as anions such as nitrate (NO_3^-), phosphates (H_2PO_4^-), and sulfates (SO_4^-). Multiple successive cropping years with high rates of added fertility can result in decreased plant water uptake, stunted growth, or a number of other problems with crop growth and development. Moving the tunnel periodically allows the land to be exposed to rainfall events and flush salinity similar to an open

field system. In the high tunnels at the University of Kentucky Horticulture Research Farm, we began to observe soil salt imbalances in our stationary (non-moving) high tunnels after five



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years of production. These salt imbalances have contributed to ripening disorders in our tomato crops to a much greater extent than we see in our movable high tunnels. How big of a problem these salts cause, and how quickly, may vary depending on aspects of soil and crop management, such as irrigation and fertilizer inputs. For more information on managing soil salinity in high tunnels, see the forthcoming High Tunnel Salinity Fact Sheet, available soon.

We should also note that there are management approaches to address these salinity and disease issues in stationary tunnels. These include removing the plastic for an extended period of time to allow precipitation to flush salts out of plant root zones and to expose pathogens to unprotected winter temperatures. Extended irrigation to flush soil salts below the rooting zone is also an option. Yet another option is disassembling and rebuilding your tunnel in a different location periodically. This will be labor intensive, and will put some wear and tear on the structure. Reassembly can be complicated as some parts may be lost, damaged, or worn over time. In addition to the labor and structural considerations, both of these options typically take land out of production. Smaller-scale modular or “caterpillar” tunnels are also growing in popularity and offer the flexibility of a light-weight structure that can be moved around the farm. They are available from several retailers such as Johnny’s Selected Seeds.

Moving a high tunnel can also help address some of the challenges of crop rotation in tunnels, where growers may feel compelled to continuously grow high value crops in the same botanical family, such as the nightshade family (e.g. tomatoes, peppers, eggplant, etc.) in the warm season, and cole crops (e.g. kale, cabbage, collards, etc.) or lettuces in the cool season. Moving the tunnel allows growers to avoid repeatedly growing the same crop (such as tomatoes) on the same piece of land season after season, while still allowing them to produce that crop in the tunnel. It also allows the grower to incorporate a cover crop as part of a rotation without taking the tunnel out of production.

Movable tunnels can also add flexibility and increased productivity to a tunnel production plan. As discussed in the “Moving Strategy” section below, a movable tunnel can be used to provide additional heat and

protection from rainfall at times when the open field conditions become less favorable. For example, the movable tunnel may be planted in early tomatoes in the spring that carry into the summer months. As temperatures begin to decrease in the early fall, the tunnel can then be moved to cover an adjacent field planted with fall crops such as leafy greens or root crops to extend this harvest through the winter. This allows multiple crops to be in the ground at the same time, with the tunnel moving to whatever crop needs the protection.

Movable tunnels offer opportunities to address high tunnel management challenges without disrupting production and can be very effective tools for sustainable soil management while still extending the season. However, taking full advantage of movable systems requires additional resources and more advanced knowledge of high tunnel production. The following sections discuss some key concepts for productive movable high tunnel management and important design and construction considerations.

Moving Strategy: What are you rotating around?

We have mentioned a variety of reasons why you would want to move your tunnels, but there are several different strategies for timing and frequency of moves. Your decisions on when to move will depend mostly on which variables you are trying to work around. Are you fitting the tunnel move strategically into your in-season rotation (i.e. moving off of spring-summer tomatoes onto a fall crop you hope to overwinter) or are you mainly trying to grow the same crop on a different patch of ground each year? If you have a complex rotation, you may consider moving multiple times per year while other rotations may only require a move once every few years. We have provided a few example rotations on the following page, but you should only use them as a starting point.

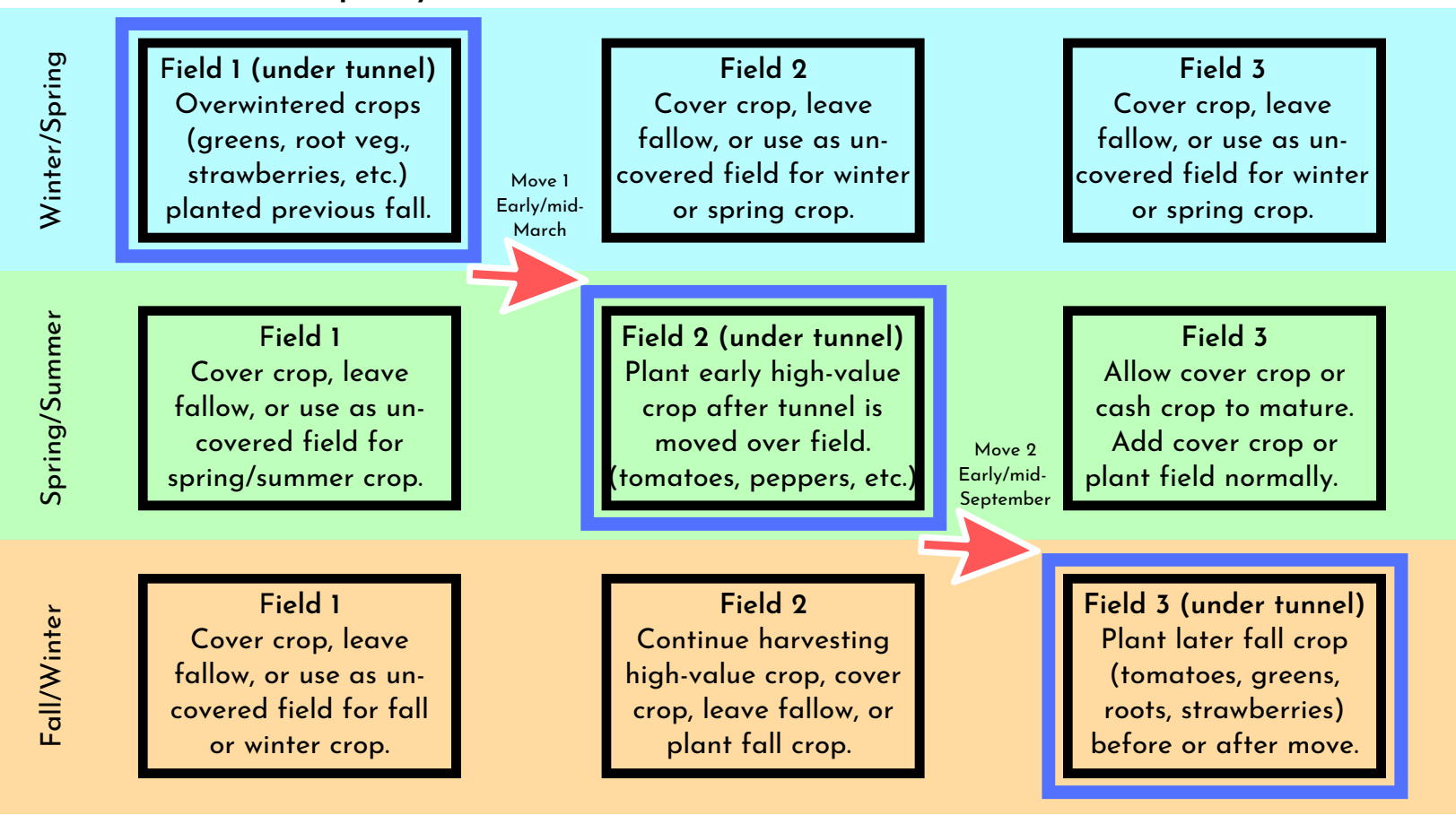
Design Elements

Most full-size movable tunnels either use a roller and rail moving system or a ski system. With these moving systems, the anchors are removed from the ground with any additional preparations needed to allow the tunnel to move freely across the ground, and the tunnel is pulled to a new field location. Modular tunnels are more portable tunnels, and are intended to

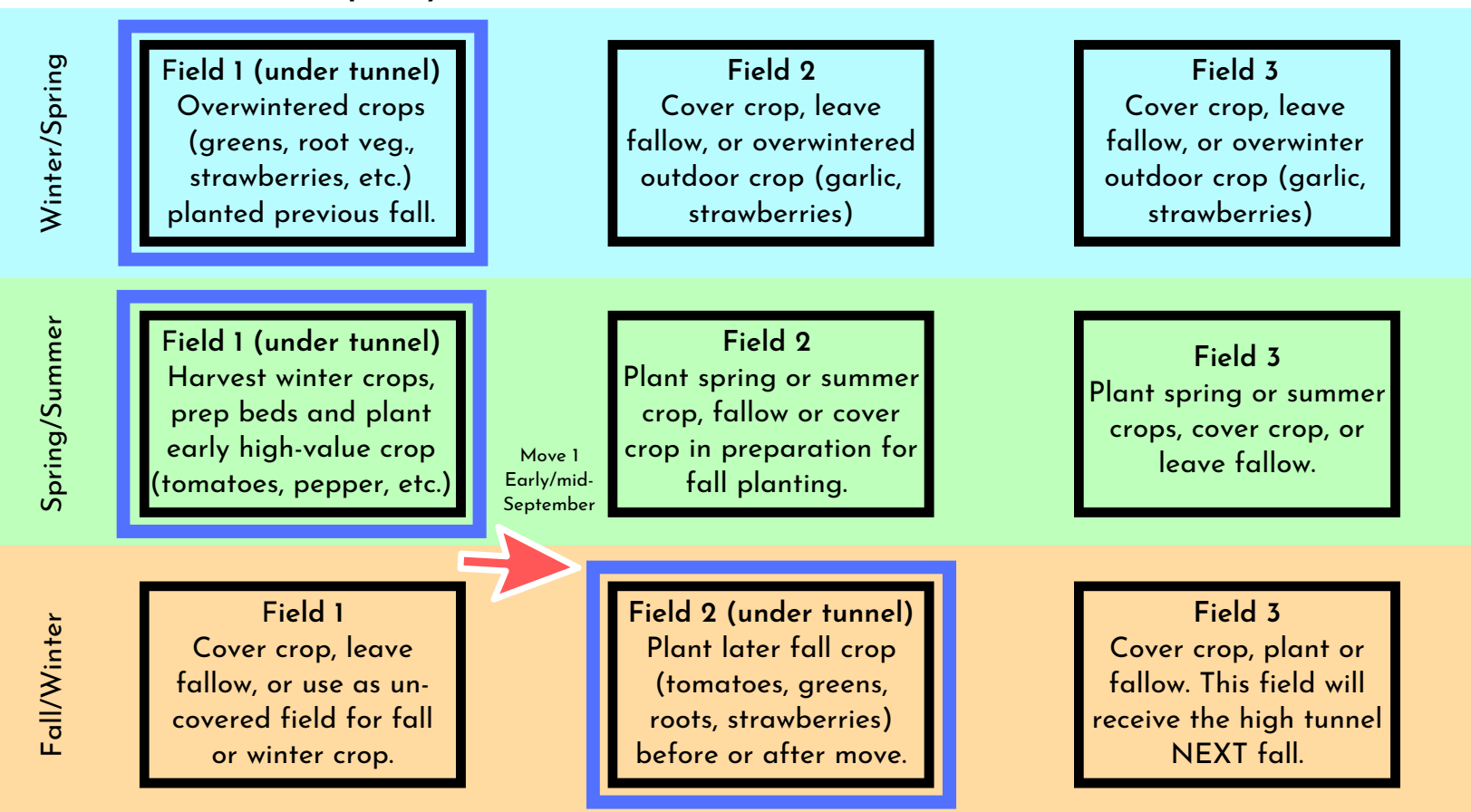
Example Rotations (3 fields available)

Each row (indicated with blue, green, and orange) represents a snapshot in time. It shows the location of the tunnel and the possible uses of each field in a 3-field setup at 3 different points across 1 season. The tunnel moves left to right across the fields. See overhead view on p. 1 for a photographic representation.

Two moves per year



One move per year



Movable Tunnel Grower Profiles *Photos: Brett Wolff and Krista Jacobsen*



Salad Days Farm - Woodford County, KY

Salad Days is an intensive market-gardening operation that uses the movable tunnel for its rotational advantages, and as a way to avoid the buildup of soil pathogens. They bought a robust stationary kit and worked with the manufacturer to add extra bracing and other adaptations to make it a movable tunnel. They generally think that movable tunnels are the way to go unless a farm is land-constrained and cannot move.



For Pete's Sake Farm - Fayette County, KY

For Pete's Sake also operates an intensive market-gardening operation. They have a movable-specific kit they purchased directly from the manufacturer. The considerable grade of their terrain poses significant challenges. They use movable tunnels because they have limited land, but want their soil to be occasionally uncovered by the tunnel. They typically move twice per year and they think about moving the heat "to the crop."



UK High Tunnel Research Facility (UKHRF) - Fayette County, KY

Since 2011, Dr. Krista Jacobsen has been working with 30' x 72' movable tunnels that were designed and built at the UKHRF. There have been multiple design changes. All the movable tunnels now use wheel and track systems (A); turnbuckle anchors secured to earth augers (trailer anchors, B); and simple curtain panel endwalls, secured with wiggle wire (C). These changes have improved efficiency in moving, decreased wear and tear, and enhanced the experience of moving the structures.



be partially disassembled, picked up, and moved to a new location. There are movable commercial kits available, but some growers may choose to build from scratch or retrofit a stationary tunnel kit to make it move.

Rollers & Rails vs. Skis

Once fully assembled and covered, high tunnels are relatively heavy structures, and it can take considerable

way are more prone to moving unevenly from side-to-side (i.e. one side may move more quickly than the other) and may be more prone to splay outward due to the camber force pushing down on the tunnel. As such, they should be stabilized across the width of the tunnel to limit splay, and great care should be taken with the towing process. It may also be useful to use a winch on each corner post (for a total of 2) to prevent pinching the endwalls in toward each other.

Most commercially available movable tunnels currently being marketed use variations on the roller and rail system. With these systems, a wheel (usually steel) is fixed to the bottom of the ground posts of the tunnels, and the tunnel rolls along tracks of metal, either round or V-shaped to keep the wheel on the track. Because the wheels reduce the amount of friction between the



Above: two different kinds of rail system. First a “v” shaped track and second a round pipe rail. Both systems work with casters. Right: the tip of a ski system. This approach uses no rails and instead slides along the ground. *Photos: Brett Wolff*

effort to move tunnels safely and intact. Ski-based systems are available from some manufacturers and generally consist of the tunnel ground posts placed on metal angle. This angle functions as a “ski” which floats over the ground as the tunnel is pulled with one or multiple towing winches. Ski systems are often an affordable way to construct a moving system, as they require little additional modification and the metal angle can be readily available at specialty metal suppliers. However, caution should be exercised when using towing winches, as the tunnels moved this

tunnel and the ground compared to a ski-based system, they are considerably easier to use. At the University of Kentucky Horticulture Research Farm, we are able to move these structures without the use of tractors using as few as six people. The tracks also help limit the outward splay of the tunnel during moving, which causes less wear-and-tear on the structure. However, as roller and rail systems are not flush with the ground, they are more prone to wind entering the structure underneath the toe board and may not be as weather-tight as other systems. Air gaps can be sealed using a variety of materials, including heavy duty plastic or other materials. Once you have decided on the type of moving system, you will need to decide whether you want to buy a commercial movable kit or adapt another kit style.

Buying a commercial kit is the most straightforward option and a number of high tunnel manufacturers now offer movable tunnels. These tunnels are



You can see the movable tunnels in action at:

<https://youtu.be/dMfwgkBP9-U>

Photo: YouTube

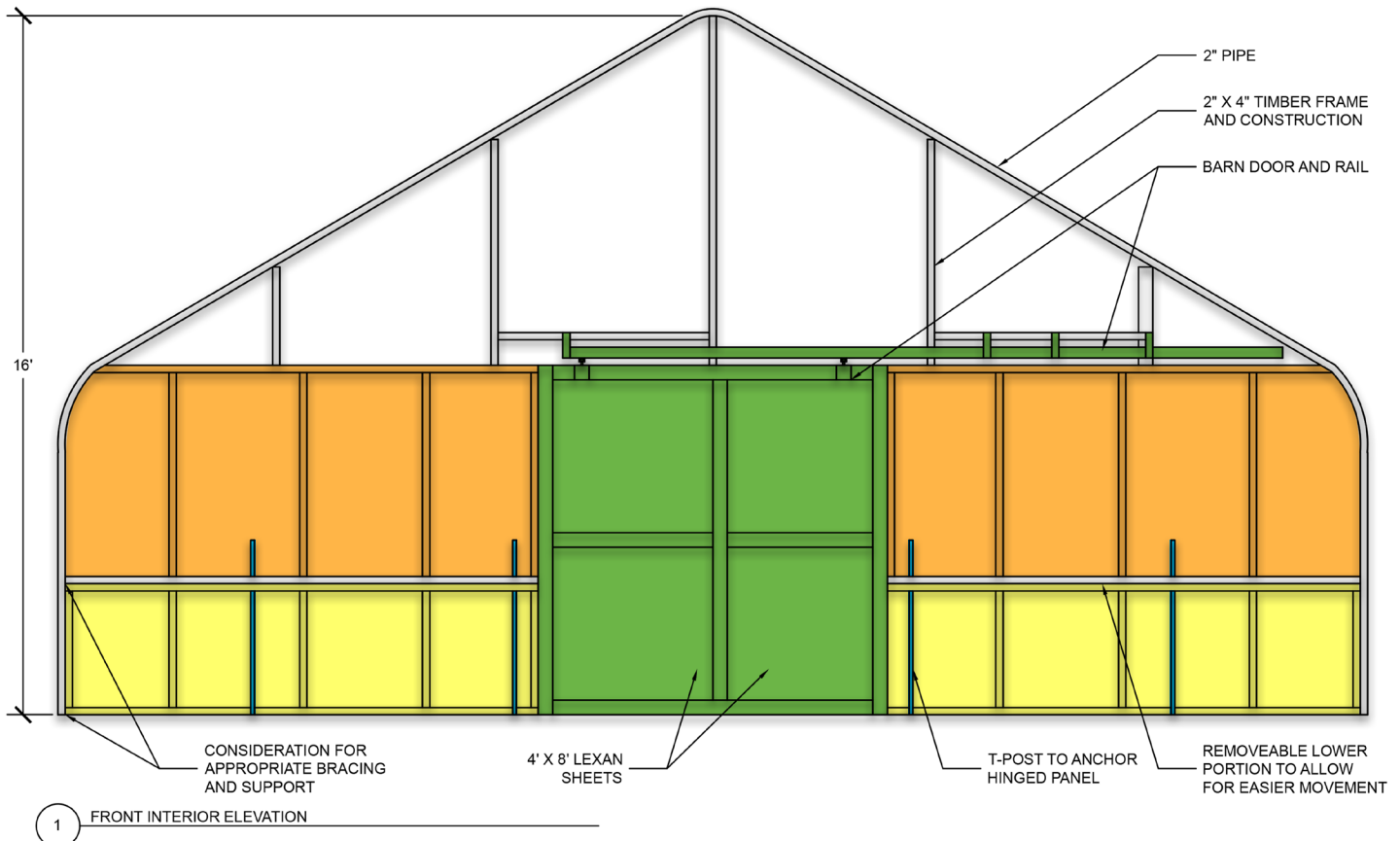
designed to move and are built accordingly. If you have any experience with building, then constructing or adapting a kit to move may be an option. Keep in mind that you are taking a kit that is not designed to move and building it to do just that. This approach may require additional bracing and other considerations in addition to the modifications required to move

the structure. Moving any structure results in wear and tear on its components and will require ongoing additional maintenance compared to a similar stationary structure. Moving tunnels may reduce the expected life of the structure relative to a typical stationary installation. Consult your manufacturer's policy regarding how modifying the tunnel will affect any warranties.

One note on tunnel size: the authors have seen movable tunnels as long as 200 feet, but that size tunnel will require considerable bracing. Most moveable tunnels are shorter than this. Keep in mind that you'll need flat fields 2-3 times longer than your tunnel so you can move it smoothly.

Anchoring

Once you have moved a tunnel to its desired location, you want to make sure that it doesn't move on its own. Wind is a major consideration even with stationary structures, and since the bows of movable tunnels are not set in the ground, it's even more crucial to plan on a strong anchoring system. There are several options



Endwalls will be one of the major design decisions you will make as you build your movable high tunnel. Some growers use rigid or folding removable panels, while others have opted for a simpler plastic curtain.

Graphic courtesy of Helen Turner, Assistant Professor, University of Kentucky College of Design

available, each with pros and cons. Whether it is from a commercial kit of your own design, movable tunnels are generally attached to an anchor buried in the ground, generally affixed to the toe board or similar point on the structure that is low to the ground.

Anchors are of various strengths, and vary from simple earth or trailer anchors, larger screw-type earth anchors, such as those used to anchor telephone poles, to permanently installed posts made of greenhouse pipe. Anchors run the length of the tunnels, generally every 4-8 feet, and are typically attached using rigid hardware to bind the structure to the anchor, such as turnbuckles or clamps. When considering an anchor system, you should consider whether you



A hydraulic-driven tool that drives anchors into the ground and helps remove them can make anchoring easier. You will need the tool and a tractor to power it. *Photo: Tim Coolong*

want your anchors to stay permanently in place, or to be removed and re-installed each time the tunnel is moved. Removing anchors can be time consuming and physically demanding, though the process can be aided by power machinery. However, having only one set of anchors that moves with the tunnel saves on the cost of additional anchors and allows flexibility to change the location to which the tunnel is moved. The importance of an effective anchor system to protect your tunnel from wind damage cannot be overstated.

End Walls

Many high tunnel kits do not come with standard end walls and instead offer end walls as an additional feature. However, most movable high tunnel kits include the end wall in the structure, and have a propriety end wall design specific to their movable high tunnel model. This is because of additional design considerations for end walls on movable tunnels. For

movable systems, it is important to remember that as the structure moves, the endwalls will need to clear anything in the tunnel's path. If you plan to move the tunnel onto already planted crops, you will need to account for the plant height, but even if you are moving onto an empty field, you will need to account for seemingly small undulations in grade, unevenness, and high spots. Growers constructing their own end walls should consider these issues of clearance when framing and designing. Several examples of end wall designs are illustrated in the *Movable Tunnel Grower Profiles*.

These designs vary in how rigid or fixed the lower portion of the end wall is. A fully framed end wall, such as those that are raised and lowered on hinges, offers additional structural stability, but may require additional soil work to ensure the end wall is flush to the ground when re-installed. If you are in a site where soil "frost heave" is a consideration, the expansion and contraction of the soil during the winter may put additional pressure on the end wall, particularly at flex points such as hinges. Another option is to finish the bottom of the end wall with greenhouse polyethylene or more durable woven polyethylene curtain material. This allows the bottom of the tunnel to be somewhat uneven and reduce soil disturbance during moves, as well as absorb any changes in soil during freezes. However, this may make the end wall plastic more susceptible to damage by wind or other factors. Care will need to be taken to secure the end wall plastic by burying or through another method.

Costs

Movable tunnels vary greatly in price, depending on how much of the construction and design a grower is considering doing on their own. In general, commercial movable kits cost approximately 50 – 100% more than a standard stationary kit of the same size. However they often include upgraded features that are optional on standard high tunnel kits, such as end walls and additional wind bracing. Stationary kits retrofitted to move may be less expensive. However, this comparison includes only the cost of materials, and not the additional labor for sourcing materials or design work, which may be considerable. Although they may cost more, movable tunnel kits do offer the advantage of designs that have been tested and technical support.

Being able to build the tunnel and grow the crops is only half of the equation. It is crucial that growers considering movable high tunnels evaluate how increases in their production costs may affect their profitability. Also, note that movable tunnels may not be eligible for NRCS EQIP funding. Talk to your NRCS service provider about your plans to verify whether your planned tunnel meets their funding requirements.

Conclusion

Movable tunnels may be the right system for a grower looking to take full advantage of the season extension possibilities and help prevent disease and soil health problems that can be associated with stationary high tunnels. This involves careful consideration of crop rotation and timing, as well as some trial-and-error to gain experience with your tunnel at your farm. Growers we have interviewed for this article were generally happy with their decision to go with movable tunnels. One noted that her system of intensive market farming fit well with the movable approach. Both noted increases in quality of their products and their soils, and said that under the right circumstances, they would recommend movable tunnels to others.

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