

Season Extension High Tunnels

This document provides an overview of several types of high tunnels used by New Brunswick vegetable growers and includes valuable information from the 2013 and 2014 growing seasons.



Caterpillar High Tunnel



Multi- Bay High Tunnel

The season extension tunnels described in this document are unheated, single layer and are generally temporary or semi-permanent structures. The caterpillar high tunnels and the multi-bay high tunnels are becoming popular because they are relatively inexpensive, \$0.40/ft² to \$1.50/ft² (caterpillar tunnels) and \$1.50/ft² to \$2.20/ft² (multi-bay tunnels), not including installation, drainage or irrigation systems. They are typically used for season extension; however, these structures can also help to protect crops from disease, insect and wild life damage thus improving the yield and quality of vegetables and small fruits. By modifying the environmental conditions, these structures may eliminate or reduce the need for pesticides and they may also extend the shelf-life of some of the high-valued crops. Extending the growing season also allows growers to receive higher prices associated with early and late season produce. Vegetable growers who have not grown crops in high tunnels in the past have also found them useful for improving farm labour efficiency during poor weather conditions that do not allow for any field work.

Since the high tunnels are not designed to withstand snow load conditions in New Brunswick, the plastic must be removed or, in some instances, rolled-up and left on top of the structure before the winter months. For additional frost protection, growers make use of row covers inside the tunnels. These row covers can be laid on top of the crops or can be supported above the crop by smaller hoops or other support systems. Since these structures cover a relatively large growing area and no rain water can reach the crops, growers must irrigate their crops. Although manual irrigation could be used in the smaller tunnels, growers generally use drip line irrigation and occasionally sprinkler systems.

Caterpillar Type High Tunnels:

These tunnels have become very popular in New Brunswick because of their affordable cost and relative ease of movement. The caterpillar tunnels are essentially a series of individual hoops covered with plastic. The plastic is held on the hoops with lacing ropes. These ropes are typically laced from one side of the tunnel to the other over the entire length of the structure. These tunnels are approximately 7 ft high in the middle of the hoop. The caterpillar tunnels are designed to allow growers to lift or pull-up the outside edges of the plastic to avoid excessive inside temperature (natural ventilation). Growers interested in producing crops that require trellis systems may want to consider tunnels that have purlins (photo 7, page 6). In most instances, purlins will significantly increase the overall cost of the tunnel structure; however, the addition of the purlins offers more structural stability.

The ropes used for lacing to hold the plastic down on the individual hoops should preferably be made of non-stretch material so fewer adjustments are needed and should be soft enough to reduce wear and tear on the plastic. These ropes are generally treated to resist ultra-violet rays. Anchors used to hold the ropes at both sides of the tunnel are generally placed near the bottom of the hoops or attached to the bottom of the hoops (i.e. small perforated plates or lacing bolts, photo 2 and 8, page 5 and 6).

Each end of the plastic sheet is tied to anchor posts located at both ends of the tunnel with pony tail style knots. In some instances, producers who use caterpillar tunnels built with light weight hoops made of plastic piping tie a rope along the very top of each hoop to keep the hoops from separating. In the majority of caterpillar tunnels, a rope is tied from the first and last hoops to each anchor posts to provide more stability. Some suppliers also promote the use of stiffeners for the same reason.

One common problem with these tunnels is that rain water tends to accumulate along the pulled-up edges of the plastic (photo 6, page 6). This water can, however, be drained rather easily once the rain event is over.

Typically, caterpillar tunnels that are well anchored are the least movable and the most expensive. Rebar type anchoring systems are generally easy to install and remove. There are other season extension structures that are even more mobile than the caterpillar tunnels. These mobile structures are generally designed with rail, wheel and/or skid systems (photos below).



Rolling Thunder Moveable Greenhouse by Rimol Greenhouse Systems, Inc
(Gore Farm, St-Stephen, New Brunswick)

<https://www.rimolgreenhouses.com/greenhouse-series/rolling-thunder>

Multi-bay Type High Tunnels:

Although the multi-bay high tunnels (photo 19) are not very popular in New Brunswick at the moment, a large number of horticultural producers in Quebec, Ontario and the United States use them. Some stakeholders consider such tunnels as non-permanent; however, the producers who use them seem to install them permanently. These tunnels are usually composed of one to four large bays of 20 to 30 ft. wide and approximately 15 ft. high at its peak. Tunnels that have multiple bays are more solid.

There are many providers and models available. Over the years, manufacturers have greatly improved their structures. Today, these structures are stronger and are equipped with options to facilitate installation and management. On very rocky sites, the installation of the screw-type ground anchors is sometimes difficult. Furthermore, growers who are planning to use multi-bay high tunnels should design and install an efficient drainage system in the areas between the bays and around the outside edge of the tunnels since there can be a sizeable amount of rain water coming off the structure (photo 20). This drainage system generally consists of a trench filled with coarse gravel and a 4 in. drainage pipe. These trenches or areas are often covered with a geotextile.

The large multi-bay high tunnels are designed so that tractors and their equipment can be used inside the structure. Also, these tunnels may be fitted with gutters and/or with electrical and automated systems to open and close the areas near the gutters, the side walls and the doors of the tunnels.

It is important to note that even if the structural components of the tunnel are not very expensive, the installation of the structure, the site preparation and the installation of the drainage and irrigation systems represent significant costs. Producers who are considering this type of tunnel should prepare a detailed budget which includes all components.

Managing Tunnels (A few important things to know):

Site selection: Regardless of whether these types of structures are movable, semi-permanent or permanent, it is very important to make sure the soil underneath the structure is well drained, fertile and as weed free as possible. Soil surface shaping of the proposed site is important and can improve the drainage characteristics for the entire area beneath and near the structure. For the larger caterpillar tunnels and particularly for the multi-bay high tunnels, growers should consider sites that are sheltered from the wind and well drained. Sites that are stony often create problems for growers who need to install screw type anchors.

Ventilation: Like with greenhouses, producers must manage the temperature and humidity in their structure. Since natural ventilation of the tunnel is usually controlled manually by raising the edges of the plastic of the caterpillar tunnels or by opening the areas near the gutters, the side walls and the doors of the multi-bay tunnels, producers must be very attentive to the inside and outside climatic conditions. Management of the natural ventilation is particularly important for tunnels because the temperature inside these structures can increase very quickly harming crops that do not tolerate excessive temperatures.

Irrigation: The importance of irrigation management is frequently underestimated in high tunnel production, particularly by producers who have limited experience with greenhouse production. The amount of water used, irrigation cycles and times of the day the irrigation is done are all aspects that are of paramount importance and need to be well understood. The use of tensiometers and visual

monitoring are very important even if the system can sometimes be operated by a timer. Producers using black plastic within the structure must lift the plastic mulch on a regular basis to determine if irrigation adjustments are needed.

Fertilization: It is best to install the tunnels on soils that are already fertile and rich in organic matter. Whether it is organic or conventional production, producers will benefit from preparing and amending their soil with organic matter in advance. Managing organic matter well will encourage good soil structure, water retention and soil biological activity that will promote higher yields and quality crops. The incorporation of compost is highly recommended, especially during the first years of production. To manage crop fertilization in tunnels, fertilization plans must be based on soil test results (traditional soil analysis). For producers who are seeking higher yields, or for sites that have very fertile soils, tissue analysis and greenhouse soil analysis are sometimes recommended.

Rotations and green manures: Crop rotation in the large tunnels is frequently a problem because the producers want to maximize revenue from their structures even though the production areas are often limited. Consequently, the producers also have great difficulty including green manures in their rotations. Short season green manure crops are generally easier to insert into the rotation and will play an important role in the biological activity of the soil.

Weeds: Management of annual and perennial weeds in tunnels is very important. The annuals must be eliminated before they produce seeds. It is best to control perennial weeds before the tunnels are installed because once they become established these weeds are very difficult to control. Some producers who failed to manage weeds during the season or in the fall are surprised by the rapid emergence of annual weeds and aggressiveness of the winter-annuals and perennials the following spring. These weeds can reduce yields and crop quality significantly and can also harbor pests (insects and diseases).

Pests frequently observed in tunnels: In general, when tunnels are well managed there are fewer pests; however, conditions found in these structures can sometimes encourage outbreaks of the following insects and diseases: tarnished plant bugs, flea beetles, spider mites, aphids, cucumber beetles, powdery mildew (on cucurbits and legumes), gray mold (on tomatoes and peppers) and tomato leaf mold.

Growers interested in high tunnel structures should make use of the internet as it is an invaluable source of information and they should also discuss all season extension options with experienced growers and agrologists.

Acknowledgement: This document was made possible with the collaboration of the following New Brunswick growers: Roger Richard, Kent Coates, Will Pedersen, Tim Livingston, David Fishman and Robin Heelis.

Disclaimer notice: Reference to commercial products, trade names or suppliers provided in this document does not constitute an endorsement by the New Brunswick Department of Agriculture, Aquaculture and Fisheries. It is important to note that other types of high tunnel systems and suppliers exist.

Caterpillar Tunnel – Nature’s Route Farm (Sackville, NB)

Multi Shelter Solution Design: (17 x 300 ft.) @ approximately \$0.89/ft² (material only)



Description of infrastructure: Tunnel sold as a kit (17 x 7.5 ft. high, by any required length)

Hoops: 1 x 2 in. bent steel, 24 ft. long, (\$35/hoop, photo 4). **Hoop spacing:** at 6 ft.

Anchoring system: 5/8 in. rebar of 4 ft length inserted in ground and in each end of hoop (18 in. out of ground) and one metal plate with two holes for each hoop end (two holes: one for the rebar and one for the S link or carabine link used to hold the rope, photo 2). **Rope:** ¼ in. polyester rope (stretch resistant).

Plastic sheet dimension: 28 x 334 ft. (6 mil greenhouse plastic).

The plastic is attached to two end anchors with pony tail style knots.

Time to install: approximately 30 man hours for a 300 ft. tunnel (10 hrs./100 ft. length)

The hoops, ropes, plastic, links, rebars and plates are supplied by Multi Shelter Solution.

Additional information: <http://www.sheltersolutions.ca/index.html>



Caterpillar Tunnel - Windy Hill Farm (McKees Mill, NB)

Johnny's Seeds Design: (12 x 100 ft.) @ approximately \$1.43/ft² (material only)



Description of infrastructure: (12 x 100 ft.), made with chain link fence material.

Hoops: Two 10 ft. swaged 1^{3/8} in. top rails from chain link fence, bent on site and bolted together (\$22/hoop). Cross connectors, ridge pole and purlins (optional and used for trellising crops) are mounted beneath the top of each hoop. **Hoop spacing:** 5 ft.

Tunnel without purlins: \$1.13/ft². **With purlins:** \$1.43/ft². It is possible to lower the cost by using #15 rebar as anchors and by using two high tensile wires instead of standard purlins (\$1.00/ft²).

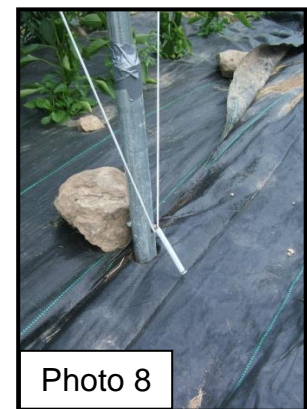
Anchoring System: 36 in. long, 1^{5/8} in. chain link fence posts bolted to hoop with lacing bolts (photo 8). **Plastic:** 20 x 125 ft. (\$299, 6 mil greenhouse plastic). **Rope:** 550 white parachute cords for lacing (\$85 for 1000 ft.).

Multi-use plastic clamps hold plastic up in warm growing conditions (\$28/14 clamps, photo 6).

Specialized equipment: Pipe bender and ground pipe/post driver. **Time to cut/bend steel and install:** 40 hrs. (12 hrs. steel work, 14 hrs. ground posts and 14 hrs. erect tunnel).

Additional information: <http://www.johnnyseeds.com/MediaPlayer.aspx?VideoID=73>

<http://www.johnnyseeds.com/Assets/Information/HighTunnelBendermanual.pdf>



Caterpillar Tunnel – Strawberry Hill Farm (Woodstock, NB)

Custom Design for Netting: (15 x 300 ft.) @ approximately \$0.40 to 0.50/ft² (material only)



Description of infrastructure: (15 x 300 ft.)

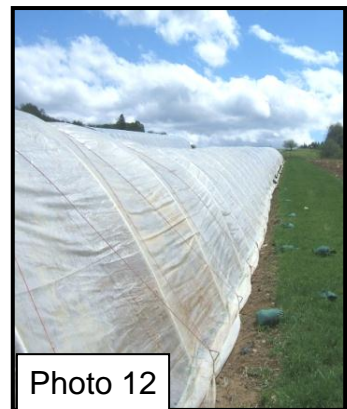
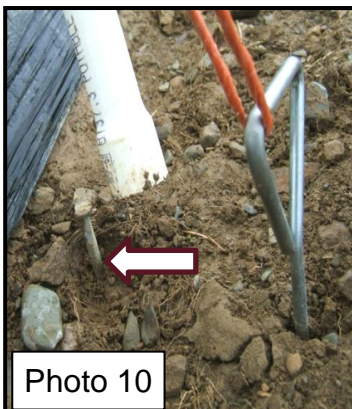
Hoops: Two 10 ft. lengths of 1 in. white PVC water pipe joined in the middle (20 ft. x \$0.75/ft. = \$15/hoop). Some growers prefer 1½ in. plastic piping.

Hoop spacing: For netting (6 ft. apart), for plastic (4-6 ft. apart).

Anchoring system: A 12 in. spike is inserted in the ground and in each end of hoop (see arrow in photo 10). The short spikes allow for a quick relocation of the tunnel. Some growers prefer to use 20-30 in. rebars. **Rope anchoring system:** Multi-use ground screws (\$4/unit) are used to hold the rope. They are located near the hoop ends. **Ropes:** Ropes consist of heavy duty baler twine (photo 10).

ProtekNet Insect Netting (60 g/m² to control tarnished plant bug), Dubois Agrinovation Product.

Additional information: <http://www.duboisag.com/en/proteknet-insect-netting.html>



Caterpillar Tunnel – Jardins Anicha (Melrose NB)

Les Serres Guy Tessier Design (14 x 208 ft.) @ approximately \$0.86/ft² (material only)



Photo 13

Description of infrastructure: Tunnel is sold as a kit (14-16 ft. wide x 8 ft. high x 104, 208 or 304 ft. long).

Hoops: Hoops are factory bent and are delivered in two pieces which need to be assembled (16 gage galvanized steel tubes). **Hoop spacing:** 8 ft. (other option: 4 to 8 ft.).

Anchoring System: ½ inch rebar, 30 in. long (18 in. ground, 12 in. into the hoop) (photo 16). Anchor screws (24 in.) are located between each hoop (photo 14 and 15). **Ropes:** ¼ UV treated polyester ropes are installed between each hoop and each end is attached to a screw type anchor (photo 14 and 15). One piece of rope is used between the hoops (unique aspect of this tunnel).

Plastic: Two sheets of 28 x 115 ft., 6 mil greenhouse plastic. **Polylocks** are used to lengthen the tunnel (photo 17). **Plastic retention hooks:** These hooks are installed on the hoops to hold the plastic up for ventilation during hot conditions (photo 18).

Metal reinforcement tubing “**Stiffeners**” are used to solidify the first and last three hoops of the tunnel. **Additional information:** <http://www.serres-guytessier.com/tunnel-chenille-2.html>

<http://www.duboisag.com/en/caterpillar-tunnel.html>



Photo 14



Photo 15



Photo 16



Photo 17



Photo 18

Multi-Bay High Tunnel - Green Thumb Farm (Acadieville, NB)

Harnois' TunnelPro Design: (28 x 200 ft. x 3 bays) @ approx \$2.10/ft² (material only)



Photo 19

Description of infrastructure: (28 x 200 ft. x 3 bays); other options: 28 – 31 ft. wide.

Anchoring System: Screw type ground posts (3.5 ft. below ground surface).

Arch spacing: 10 ft. **Side wall height:** 60 in. **Height:** approx. 15 ft. at the highest point of each bay.

Plastic sheets are secured with 1 in. UV resistant nylon straps. In the fall, the plastic is rolled-up and left at the top of each bay to facilitate its installation the following spring. The rolled-up plastic is protected from the winter conditions by tarps or shrink-warp material.

Areas located between bays are well drained via a drain tile covered with coarse gravel and landscape fabric (photo 20). Inside and outside walls have roll-up ventilation systems.

Doors: Two curtain doors made of laminated polyethylene which overlap each other slightly in the middle of each bay opening (photo 19 and 21).

Steel components are swedged, curved and pre-drilled before delivery.

Additional information: www.harnois.com/images/stories/accueil/Brochures/ANG_TunnelPro.pdf



Photo 20



Photo 21