UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY — COLLEGE OF AGRICULTURE

Greenhouses and Similar Structures

Introduction

Thanks to the pioneering work of Dr. Emery Emmert, "The Father of the Plastic Greenhouse," at the University of Kentucky in the late 1940s and early 1950s, the types of greenhouses available today are much more diverse than many may realize. While the traditional glass greenhouse is still with us, we now have many alternative types of structures that can effectively extend the growing season. These range from very simple greenhouse-like structures (low tunnels) to field greenhouses (high tunnels with or without heat) to the more conventional greenhouses and to greenhouse complexes of 40 acres in size or more.

A greenhouse is essentially a "tool" that can be used to facilitate the growing of plants. Generally, the tool is fitted for the job, and not the other way around. Growers need to determine what plants will be produced before making a decision about the type of greenhouse needed to accomplish the job.

Depending on the crops to be grown, a conventional greenhouse may not even be needed. Instead, a simpler structure could more economically extend the growing season into spring and fall. For example, if the primary target is an early start date for farmers markets, row covers or a field greenhouse may be quite adequate to handle the job. Even when a greenhouse is desirable, it may not be necessary to provide heat since many commercial greenhouses experience a lull in production during winter due to low natural light conditions.

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Types of Greenhouse Structures

Low tunnels

Low tunnels are basically row covers supported on wire hoops. They are often used in conjunction with black plastic mulch and drip irrigation. The covers are generally in place for only three or four weeks and then removed. Besides providing an excellent means of extending the growing season, low tunnels also offer wind protection.

Once hoops are set, the plastic cover is applied with the edges of the plastic secured by burying in the soil. Modifications have been made on this basic design to allow for daytime ventilation when temperatures within the plastic begin to rise to dangerous levels. While cucurbits are more tolerant of high temperatures, ventilation is a must for some crops such as tomato and pepper. One way to provide ventilation is to simply place slits in the plastic to allow the heat to escape. An alternative system involves using two narrower sheets of plastic with a seam at the peak of the hoops. This seam is secured by clothespins, which can be removed to open the tunnel for ventilation. Another method, the double hoop system, makes use of two hoops with the plastic sandwiched between them. Because the edges of the plastic are not buried, the sides of the

tunnel can be raised and lowered as needed for ventilation.

High tunnels

The field greenhouse of Dr. Emmert's day is now generally called a "high tunnel" by vegetable producers, an "overwintering Quonset" by nurserymen and a "cold frame" by those in the bedding plant industry. Regardless, it is a simple, relatively permanent stand-alone greenhouse up to 15 feet wide and 8 to 9 feet high, with or without heat. It can be placed over ground beds so you are essentially gardening in a greenhouse. Vegetables, small fruits and flowers can be grown using high tunnels.

High tunnels generally have Quonset-shaped frames covered with a single layer of greenhouse-grade polyethylene. The frames can be constructed of metal pipe or wood. There can be problems in attaching the plastic to the wood frame, and in this regard metal pipe is easier to work with. Research is being conducted on the use of PVC frames; however, additional work still needs to be done before recommendations can be made.

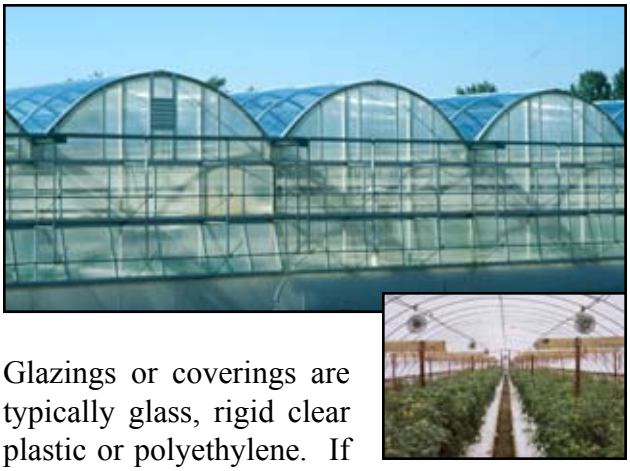
The plastic cover is put into place on the first of February after which seed is sown. The cover can be removed after the last frost-free date in mid-May and then replaced October 1. Soon after Thanksgiving, the cover should be removed to prevent damage from snow build-up.

High tunnels are ventilated by manually rolling up the sides each morning and rolling them back down in the evening. Pennsylvania State University has developed a design in which the end walls are hinged and a small tractor or tiller can be driven in. New Hampshire's system uses plastic mulch to cover the entire soil surface under the tunnel, making tilling unnecessary. High tunnels do not have any external connections, except for the water supply for trickle irrigation. While they do not have a permanent heating system, some growers choose to have a portable heater available for unexpected drops in temperature.

While lacking the precision of the environmentally controlled greenhouse, high tunnels do moderate the environment sufficiently to improve crop growth, yields, and crop quality. The yield is often double the amount that could be produced in the field without the tunnel. A combination of an earlier planting date, along with the more rapid ripening that occurs within the tunnel, can result in mature tomatoes as much as one month earlier than field tomatoes. In addition, when vented properly, serious foliar and fruit diseases are often fewer since plant surfaces remain dry while in the protective environment of the high tunnel.

Conventional greenhouses

Conventional greenhouses may be 20 feet or more in width and 100 feet or more in length with frames of aluminum, galvanized steel or wood.



Glazings or coverings are typically glass, rigid clear plastic or polyethylene. If only a single greenhouse is required, it can be built as a stand-alone unit. However, when multiple houses are needed (either initially or as part of a future expansion) the greenhouses should be gutter-connected for more efficient use.

The greatest advantage to a conventional greenhouse is the ability to completely control the environment to suit the plants being produced. Today this is called controlled-environment agriculture, or CEA. These greenhouses have heat, mechanical ventilation and an irrigation system which can also be used to distribute liquid fertilizer. A monitoring device is essential for determining whether the greenhouse conditions are within the proper range the crop requires. Greenhouses may also have benches and various other machinery and hand equipment to aid in the production and handling of the crop.

Greenhouse conditions that favor plant growth also favor the rapid build-up and spread of insects and diseases. Prevention and careful monitoring are the keys to insect and disease control. Water aeration in the irrigation system can help to reduce water molds. Insect screening on the sidewalls may be necessary for some crops if sidewall ventilation is used. Pesticides must be applied properly and legally. Weed control under benches and around the greenhouse will also help reduce insect pests and disease problems; however, herbicides are not applied in greenhouses.

Economic Considerations

Crop production in a conventional greenhouse can be a highly profitable venture. However, it is also a high risk business with significant start-up costs, as well as demanding labor and management. Initial investments include greenhouse construction, production system costs and equipment. The cost of a production-ready greenhouse, excluding land costs, can run between $8 and $30 per square foot.

Low tunnels and high tunnels are relatively inexpensive ways to extend the growing season, requiring little capital investments. Excluding labor, the approximate cost of a low tunnel is $0.25 per square foot, with high tunnels costing $1.30 per square foot. Because of their simple design, these structures are not difficult to construct and manage. Tunnels are not automated in any way, so they will require daily attention and labor to ensure proper ventilation. Both types of tunnels could also require monitoring during heavy storms.

More Information

- The Greenhouse Business in Kentucky – A Review of Crops and How to Begin a Business (University of Kentucky, 2002)
http://www.uky.edu/Ag/Horticulture/anderson/greenhousesinkentucky.pdf
- Selected Resources and References for Commercial Greenhouse Operators (University of Kentucky, 2002)
http://www.uky.edu/Ag/Horticulture/anderson/greenhousereferences.pdf
- Center for Plasticulture (Pennsylvania State University)
http://plasticulture.cas.psu.edu
- Greenhouse Structures (Arizona, 2001)
http://ag.arizona.edu/ceac/research/archive/structures.htm
- National Greenhouse Manufactures Association - *Book of Greenhouse Structural Standards can be downloaded for free from here*
http://www.ngma.com
- Season Extension Techniques for Market Gardeners (ATTRA, 2005)
http://attra.ncat.org/attra-pub/seasonext.html
- Starting a Greenhouse Business (Part 1): Some Basic Questions, FSA-6051 (Arkansas, 2004)
http://www.uaex.edu/Other_Areas/publications/PDF/FSA-6051.pdf
- Starting a Greenhouse Business, B-1134 (Georgia, 1998)
http://pubs.caes.uga.edu/caespubs/pubcd/b1134-w.html
- Texas Greenhouse Management Handbook (Texas A&M)
http://aggie-horticulture.tamu.edu/GREENHOUSE/nursery/guides/green/index.html

Construction plans

- How to Build a High Tunnel (University of Kentucky)
http://ces.ca.uky.edu/robinsonstation/Horticulture/how_to_build_a_high_tunnel.htm

- Greenhouse Plan List (University of Kentucky)
http://www.bae.uky.edu/Publications/pubs_AEN.htm

A listing of plans for a number of different greenhouse structures is included on this Web page. Some plans can be downloaded directly from the Web site; however, most must be ordered. Make your request to:

University of Kentucky Plan Service
Biosystems & Agricultural Engineering Dept.
Lexington, KY 40546-0276
Phone: (859) 257-3000 Ext.111
FAX: (859) 257-5671
e-mail: jpeel@bae.uky.edu

- Design and Construction of the Penn State High Tunnel (Pennsylvania State University article in HortTechnology, 2002)
http://plasticulture.cas.psu.edu/Design_construction.pdf
- Greenhouse Plans, IS-941 (Mississippi State University)
http://msucares.com/pubs/infosheets/is0941.htm

Blueprints for small greenhouses can be obtained from the MSU address listed on the above Web site.

- Portable Field Hoophouse (Washington State University Extension, 1997)
http://cru.cahe.wsu.edu/CEPublications/eb1825/eb1825.html