Extending the Production Season with High Tunnels

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Introduction

For centuries a wide variety of techniques have been used to extend the growing season of horticultural crops. glass jars; glass cloches, hotcaps, cold frames, hotbeds, and greenhouses of various types have all contributed to season extension. More recently high tunnels have become popular with growers because of their simplicity and effectiveness in protecting crops from low temperatures, wind, and moisture stress in both spring and fall.

High tunnels do not offer the precision of conventional greenhouses for environmental control, but they do sufficiently modify the environment to enhance crop growth, yield, and quality. Although they provide some frost protection, their primary function is to elevate temperatures a few degrees each day over a period of several weeks.

In addition to temperature control, there are also the benefits of wind and rain protection, soil warming, and in some instances control of insects, diseases, and predators such as rodents and birds. Overall, this growing system should be considered a protected growing system that enhances earliness and promotes higher yields, improves quality and shelf life, and reduces the use of pesticides.

High tunnels have sufficient versatility to make them useful on a wide diversity of crops and in various cropping systems. Vegetables, small fruits, flowers and even tree fruits are all suited to this growing system; but the specific crops which might be grown will to a large extent depend on marketing opportunities for individual crops by individual growers.

High Tunnel System

High tunnels encompass a crop growing system that fits between row covers and greenhouses. They are relatively inexpensive (about $3.00/sq. ft, excluding labor), permitting a grower to enter into high tunnel crop production with limited capital. This system is particularly appealing to new-entry growers who utilize retail-marketing channels.

High tunnels are not conventional greenhouses. But like plastic-covered greenhouses, they are generally a peaked quonset-shape, constructed of metal bows that are attached to metal posts which have been driven into the ground about two feet deep. They are covered with a single layer of 6-mil greenhouse-grade polyethylene, and are ventilated by manually rolling up the sides each morning and rolling them down in early evening. There is no permanent heating system although it is advisable to have a standby portable propane heater to protect against unexpected below-freezing temperatures. There are no electrical connections. The only external connection is a water supply for trickle irrigation. Dr. Otho Wells, from the University of New Hampshire, was a pioneer in promoting the use of high tunnels in the northeastern United States and developed the New Hampshire design and system of production that involved covering the entire soil surface inside the tunnel with a solid sheet of 6-mil thick plastic. At Penn State we re-

designed the endwalls so that they can be raised up to facilitate easy access into the tunnel with a small tractor and tiller and a system of production that uses 18- inch wide raised plastic mulch covered beds with drip irrigation tape buried 2-3 inches beneath the bed. The raised mulch beds are 44 inches apart, which allows 4 rows in a 17 foot wide high tunnel or 5 rows in a 21 foot wide tunnel.

General Suggestions for High Tunnel Management

High tunnels are not automated. Consequently, for maximum efficiency, they require regular daily attention, especially in the morning and evening, and during heavy rain events or strong winds. Temperature and humidity are the two critical factors that should be controlled as much as feasible. Early each morning, the sides should be rolled up to flush out the humidity and to keep temperature in check. The temperature in a closed high tunnel rises very rapidly on a clear morning! In other words, don't put off rolling up the sides. Ken-Bar Inc., Reading, MA. has developed a top vent that fits right on the plastic and can be used to ventilate a tunnel in the early spring and late fall when one does not really need to roll the sides up for temperature control. In the early evening, roll down the sides to entrap as much heat as possible. To increase soil and air temperatures within a high tunnel the following materials have been used successfully over the last four years: floating row covers, thermal blankets, hoop supported low tunnels (plastic film with or without ventilation holes or row cover material). Close the sides each evening until the night temperature reaches about 65^{o}F. In the northeastern United States, this could mean that the sides would be rolled down each day well into the summer. Ventilation is best accomplished when wind moves through the tunnel from side to side; therefore orient the tunnel accordingly. The width of the tunnel also impacts ventilation. It is hard to be specific on the maximum width, but from experience, about 21-26feet seems to be the maximum high tunnel width that will allow for good ventilation, especially as plants grow taller and block the airflow.

Benefits of High Tunnels

The primary benefit of high tunnels is earliness. Tomatoes in a high tunnel mature on average about one month before field tomatoes. Earliness is the combination of being able to plant in high tunnels about two weeks earlier than in the open- field and faster ripening (about two weeks) inside the tunnel. Overall, the cost of a tunnel is usually recovered the first year when selling at retail prices. Another highly beneficial advantage of tunnels is disease control. The plastic cover acts like a rain shelter, the raised plastic mulch beds are a barrier against evaporation of soil moisture, and early morning ventilation reduces relative humidity. Therefore, the leaves of crops are dry for most of the day and night. Because of low humidity, plant leaves remain dry, impeding the incidence and spread of disease. Powdery mildew is the most serious and prevalent disease in high tunnels because the conditions in a high tunnel are more favorable for the development of this disease.

Crops

The following crops have been grown successfully in the high tunnels at Penn State High Tunnel Research and Education Facility.

Vegetables

The high tunnel allows growers to produce crops over a longer period of time and in some climates even produced year-round. Many times the plastic mulch is double-cropped with the first crop being removed and the second crop being planted on the plastic. The following vegetables have been grown successfully in the high tunnels: tomato (*Lycopersicon esculentum*), eggplant *(Solanum melongena*), pepper (*Capsicum annuum* Grossum group), muskmelon *(Cucumis melo*) summer squash (*Cucurbita pepo*), cucumber *(Cucumis sativus*), spinach (*Spinacia oleracea)*, Swiss chard (*Beta vulgaris var. cicla)* , lettuce (*Lactuca sativa*) , broccoli (*Brassica oleracea* var. *italica*)., cabbage (*Brassica oleracea* var. *capitata*), cauliflower (*Brassica oleracea* var. *botrytis*), kale (*Brassica oleracea* var. *acephala*), kohlrabi (*Brassica oleracea gongyloides*), okra (*Abelmoschus esculentus*), onions (*Allium cepa)*, leeks (*Allium ampeloprasum porrum)* , garlic (*Allium sativum)*, peas (*Pisum sativum*), specialty potatoes (*Solanum tuberosum*) for the red, white and blue potato salad for the 4th of July. In addition, a wide variety of herbs such as dill (*Anethum graveolens*) have been grown in the high tunnel.

Small Fruits

The extended production season and improved shelf-life of these products make high tunnel production a very viable option for the direct marketer. Primocane-bearing red raspberries (*Rubus idaeus)*, and thornless blackberries (*Rubus subgenus Eubatus)* are produced on bare ground with drip irrigation. Strawberries (*Fragaria x ananassa)* are grown using the small raised bed with drip irrigation.

Cut Flowers

There are many options for cut flowers in the high tunnels ranging from herbaceous perennials over-wintered for spring cut-flower production to summer annuals, and natural season fall mums. This production system permits cut flowers to be harvested earlier in the spring and later in the fall compared to cut flowers grown in the field, and provides excellent flower quality.

Tree Fruit

Sweet cherries on dwarfing rootstock have been planted in high tunnels since 2000. Generally fruit tress are grown in large multiple bay temporary high tunnels such as those sold by Haygrove US. Benefits of growing sweet cherries in high tunnels appear s to be earlier maturity, elimination of fruit cracking and bird damage.

Summary

High tunnels can provide an ideal protective growing environment for any number of crops, but all crops might not be economical for any number of reasons. Therefore, a good approach to take would be to try different crops in light of market demands and marketing strategies. Although tunnels do require more manual attention than do greenhouses, the benefits

of high tunnels in a diversified farm operation have proven to be a valuable asset in overcoming a short growing season and expanding the marketing season.

There are temperature limitations in high tunnels since they are not designed to be as warm as a greenhouse. Some type of supplemental heat should be available just in case there is a sudden unexpected drop in the temperature that would permanently injure the crop. The critical low temperature will depend on the crop. If the intent is to have a permanent heat source in a high tunnel, then if would be well to consider constructing a bona-fide greenhouse which easily could be used year around.

For addition information on plasticulture contact the following websites:

American Society for Plasticulture: **http://www.plasticulture.org/**
Center for Plasticulture, Penn State University: **http://plasticulture.cas.psu.edu**

Penn State High Tunnel Production Guide is available for $30.00 U.S. dollars from

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