Horticulture

UtahStateUniversity
COOPERATIVE EXTENSION

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April 2010 **Horticulture/HighTunnels/2010-04**

Temperature Management in High Tunnels

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Introduction

High tunnels have proven to be an effective method for extending the growing season for a number of high-value crops in a diverse range of climates. High tunnels are large plastic covered structures that are used to modify the growing conditions of the covered area. High tunnels are similar to greenhouses, except that warming and cooling of high tunnel is usually entirely passive, where expensive cooling fans and heaters are often used in greenhouses.

High tunnels are used for cold protection, and to provide optimal growing conditions for longer periods of time. The key to tunnel management is to understand the temperature requirements of the crop. This fact sheet spells out temperature considerations and how these are best addressed using high tunnels and other season-extending technologies.

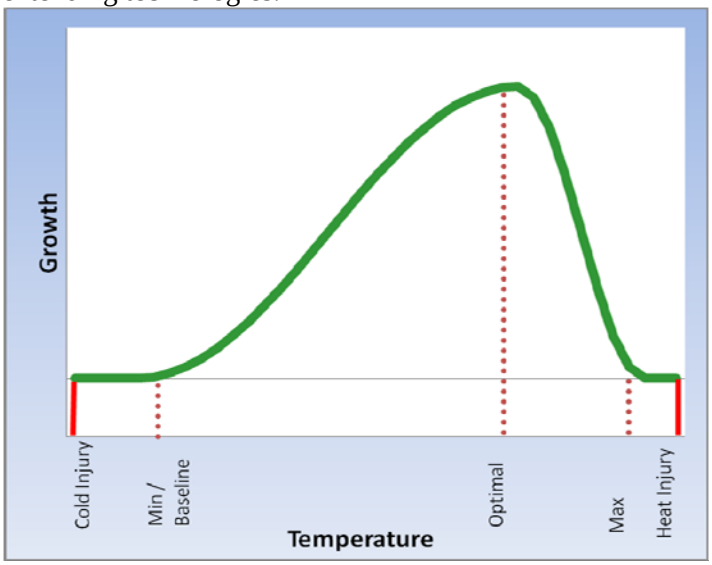

Figure 1. Typical relationship between temperature and plant growth rate.

Temperatures and Growth

Figure 1 shows the typical relationship between temperature and plant growth. At the left side of the graph is a point where temperatures are cold enough to cause plant injury. When temperatures are above that point, the plant may survive un-injured, but may not grow until temperatures exceed the minimum or base temperature for growth. As temperatures increase above the base, the plant growth rate also increases up to the point where temperature is optimal and plant growth is maximized. As temperatures exceed the optimum, then plant growth slows until the point where heat injury begins to take place.

The "critical" or "cardinal" temperatures are the minimum, optimum and maximum temperatures that define this growth curve, and these temperatures differ from crop to crop. A cool season crop like lettuce can withstand colder temperatures than a warm season plant like watermelon. Cool season plants also have a lower optimum temperature than do warm season crops. Therefore, they tend to undergo heat stress symptoms at lower temperatures. The cardinal temperature for seed germination and plant growth of some common fruit and vegetable crops is shown in Tables 1-3.

Table 1. Cardinal temperature for fruit crop growth.

Crop	Minimum (°F)	Optimum (°F)	Maximum (°F)
Strawberry	40	65-75	85
Raspberry	40	65-75	90
Blackberry	40	75-85	95

Temperatures Management

High tunnels are heated when sunlight warms the plants and soil. The warmed plants and soil reradiate the heat, warming the air within the tunnel. Temperatures within a closed tunnel can increase rapidly on sunny days even when outside air temperatures are relatively cold. Even in late winter, it is often necessary to ventilate tunnels on sunny days to prevent the temperatures from exceeding the crop's growth optimum. One of the key management tools is to situate

Table 2. Cardinal temperature for seed germination of select vegetables.

Crop	Minimum (°F)	Optimum (°F)	Maximum (°F)	Ideal range (°F)
Asparagus	50	75	95	60-85
Bean	60	80	95	60-85
Bean, lima	40	85	85	65-85
Beet	40	85	95	50-85
Cabbage	40	85	100	45-95
Carrot	40	80	95	45-85
Cauliflower	40	80	100	45-85
Celery	40	70	85	60-70
Chard, Swiss	40	85	95	50-85
Corn	50	95	105	60-95
Cucumber	60	95	105	60-95
Eggplant	60	85	95	75-90
Lettuce	35	75	85	40-80
Muskmelon	60	90	100	75-95
Okra	60	95	105	70-95
Onion	35	75	95	50-95
Parsley	40	75	90	50-85
Parsnip	35	65	85	50-70
Pea	40	75	85	40-75
Pepper	60	85	95	65-95
Pumpkin	60	90	100	70-90
Radish	40	85	95	45-90
Spinach	35	70	85	45-75
Squash	60	95	100	70-95
Tomato	50	85	95	60-85
Turnip	40	85	105	60-105
Watermelon	60	95	105	70-95

From Knott's Handbook for Vegetable Growers (4th Edition).

an accurate minimum-maximum thermometer in the house and use it to track daily low and high temperatures. Carefully following tunnel temperatures is essential to developing management strategies for maintaining optimum plant growth conditions.

Opening the end doors or vents is the first step in ventilation and temperature regulation. If this does not sufficiently reduce the temperature then the side walls can also be opened (Figure 2). Doors should be closed in the late afternoon to retain heat through the night time. Low tunnels placed over individual rows of crops within the high tunnel can add an additional "temperature lift" to prevent cold damage at night (Figure 3). Low tunnels also require careful ventilation to prevent extreme high temperatures. Without proper ventilation of both high and low tunnels, temperatures in a Northern Utah high tunnel have exceeded 120°F on a sunny day in early March.

Figure 2. Side ventilation of a tomato high tunnel.

Figure 3. Low tunnels within a high tunnel.

Later in the spring, as the day and night temperatures remain above the minimum for the crop, the plastic can be removed from the tunnel and replaced with shade cloth to reduce the risk of sunburn or other heat stress.

Table 3. Cardinal temperature for growth of selected vegetables.

Crop	Min. (°F)	Opt. (°F)	Max. (°F)
Chive, Garlic, Leek, Onion	45	55-75	85
Beet, Broad Bean, Broccoli, Cabbage Chard, Collards, Kale, Parsnips Radish, Spinach, Turnip	40	60-65	75
Artichoke, Carrot, Cauliflower, Celery Endive, Lettuce, Mustard, Parsley, Pea, Potato	45	60-65	75
Lima Bean, Snap Bean	50	60-70	80
Sweet corn	50	60-75	95
Pumpkin, Squash	50	65-75	90
Cucumber, Muskmelon	60	65-75	90
Sweet Pepper, Tomato	65	70-75	80
Eggplant, Hot Pepper, Okra, Sweet Potato, Watermelon	65	70-85	95

From Knott's Handbook for Vegetable Growers (4th Edition).

This publication is issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Noelle E. Cockett, Vice President for Extension and Agriculture, Utah State University.