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Supplemental Heating in a High Tunnel

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High tunnels are a relatively low-cost way to extend the growing season and provide frost protection in temperate climates. These greenhouse-like structures are becoming increasingly common for commercial and backyard small fruit and vegetable production. During the day, high tunnels are passively heated by shortwave radiation from the sun. The incoming radiation is absorbed by the soil and plants and is trapped by the plastic covering, resulting in a temperature increase inside the tunnel. At night however, much of this radiant heat is lost and the tunnel air temperature approaches outside ambient conditions. Consequently, supplemental heating is sometimes needed to bring plants through a particularly cold night.

One of the benefits of using supplemental heating in a high tunnel is to protect plants from cold temperatures that would otherwise adversely affect growth. In the early spring and late fall, cold night-time temperatures can slow growth through chilling injury, or freezing damage. For warm season crops, like tomatoes and peppers, chilling injury occurs when air temperature is below 50 °F and above freezing. Although chilling injury does not kill the plant, it will slow growth and move production later in the season, which undermines one purpose of the high tunnel. Freezing injury kills part or all of the plant. If only part of the plant is killed, re-growth is required to replace injured tissues, which delays production (Image 1). Warm season vegetables are particularly sensitive to freezing injury while cool season crops can withstand some cold.

Supplemental heating may be necessary to keep plants from chilling or freeze injury and may move production earlier. There are two main ways to heat a high tunnel, by in-ground and above-ground heating. In-ground heating is installed before planting and is usually set to heat the soil to a certain temperature, often in hopes of further season extension. Above-ground heating involves heating the air around the plants, and is typically used to protect against very cold night temperatures but may not be practical for long-term use.

Image 1. Freeze injury on pepper results in replacement growth (or plant death) next to plant without injury.

In-Ground Heating

Warming the soil in the spring has been shown to increase early plant growth, and in some cases move the production window earlier than a high tunnel alone. Two common methods of heating the soil are buried electric heating cables (Image 2) and pumping hot water through buried hoses or pipes (Image 3).

Image 2. Buried electric heating cables.

Image 3. Hot water is pumped through flexible tubing buried in the soil.

Heating cables can be purchased from various manufacturers (online) or, from local sources. Heat cables, if installed properly and handled carefully, can be reused for 2 to 4 years. They require an electricity source and care needs to be taken not to damage the insulation around the cable both during installation, and for the life of the planting. Cables are connected to a thermostat that can be set to different temperatures, depending on plant needs. When the soil cools to the set temperature, the cables will automatically turn on and begin warming the soil.

Hot water can also be used to warm the soil and is pumped through buried pipe. The water can be heated with a hot water heater (gas or electric), from a geothermal source or by a wood-burning boiler. The piping can be flexible rubber, PVC or metal and can vary in size from a ¼ to ¾ inch.

Heating material are laid out in a serpentine pattern below the planting bed (Image 4). Bury the cable/pipe about 2 inches below the soil surface. In order to avoid damage to heating cables, it is important not to allow two parts of the cable to touch, as the combined heat may damage the insulation. The cables/pipes can be removed and stored after the growing season to allow for cultivation and bed preparation.

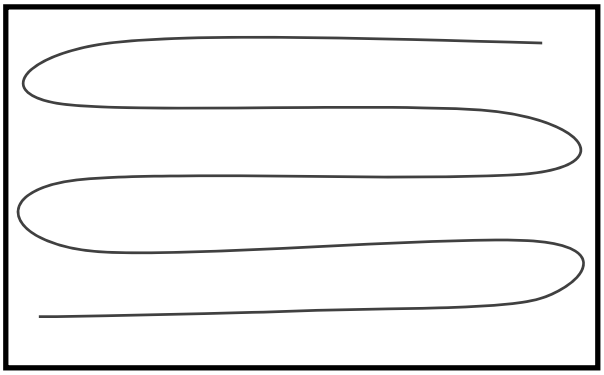

Image 4. Serpentine pattern of buried cables/pipe.

Above-Ground Heating

There are several different options for heating the air inside a high tunnel. Since the heating is temporary, many growers use a portable heater powered by propane or electricity (Image 5). The number of heaters necessary to heat a high tunnel will vary by size of heater and of tunnel. For a 100 ft tunnel, placing one heater near each end with fans to help mix the air should provide enough heat for the tunnel. More permanent options are available, but may change the classification of the tunnel from a temporary agricultural structure to a permanent building, resulting in additional building and zoning regulations. It is important to know your area's building codes before deciding on a heating method.

Passive Heating

Another approach to warm the tunnel at night is to place large water filled barrels in the tunnel. During the day the water is heated by the sun, and stored heat is released at night. While in theory this works, in practice there are limitations to this method. To provide enough heat, it is recommended to have 2.5 gallons of water per square foot of plastic covering. The USU high tunnel (14 x 96 ft) is covered with over 2200 ft^2 of plastic. Therefore, you need 5500 gallons of water (2200 * 2.5 gallons) or 100, 55-gallon barrels. A standard 55-gallon barrel has a diameter of 2 feet and would occupy 3.14 ft^2 (or314 ft^2 of tunnel space) or about 25% of the growing area. Even if you could double stack them, a lot of valuable space is lost. In addition to the loss of space, water barrels may shade the plants, further

Image 5. Temporary propane heater.

affecting plant growth. The small amount of heat released at night, the loss of space, plus the cost of the barrels may not justify their use. Further, dark colored moist soil acts as a similarly-effective reservoir of heat storage, and has the added benefit of supporting plant growth.

Research Findings

In-ground supplemental heating has been beneficial for several crops grown in greenhouses in North Logan, Utah. Table 1 shows the effect of in-ground heating when used in conjunction with both a high tunnel and low tunnel. Using a low tunnel inside of the high tunnel further increases air temperature around the plant. Learn more about low tunnels at tunnel.usu.edu. For each crop, the use of supplemental heating in conjunction with a high tunnel increased the total yield above the high tunnel alone.

Table 1. Effect of heat cables on the yield of different high tunnel crops. Low tunnels were used for both no heat and plus (+) heat treatments.

	Tomato kg/plant	Spinach g/plant	Strawberry g/plant	Early Peppers g/plant
No-heat	5.01	11.8	628	94
+ heat	5.51	17.7	924	245

Conclusions

Both above and in-ground supplemental heating can increase high tunnel fruit and vegetable production. In-ground heating is a more efficient heating method as it targets just the soil the plant is growing in. When using above-ground heating the entire air space of the tunnel is heated, increasing cost. This additional cost is often justifiable when used infrequently on very cold nights. However, for long-term consistent heating above-ground heating may not be economically viable.

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