Using Solar Energy to Heat the Soil and Extend the Growing Season in High Tunnel Vegetable Production

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This project was conducted in far northern Minnesota, about 120 miles south of the Canadian Border near Detroit Lakes Minnesota. The growing zone for this area is between 2b and 3a, which means that we get winter lows occasionally of -50 F, but more commonly of -40. Frost free days are from June 10th through Sept 12, which often makes growing warm season crops such as tomatoes a challenge.

The project started in 2008, with the constructing of a high tunnel that uses solar heat to warm the soil below the tunnel. Hot air is pumped from three solar panels through a series of corrugated tile lines buried beneath a 30' x 48' high tunnel. Only using solar heat, the soil and air temperature in the heated tunnel stayed at a minimum of above 45°to 50F from March 14 until nearly Dec1. Starting in 2009, we were able to compare temperatures, planting dates, and harvest dates in the heated high tunnel with a nearby unheated tunnel. We planted tomatoes in the new tunnel 6 weeks earlier and began harvesting tomatoes and cucumbers 8 weeks before the unheated tunnel. Besides heating the soil, which also acts as a heats sink we were able to drastically alter the air temperature of the high tunnel at night and cold days. Several versions of this project have been built by different producers. If this system was used in milder climates, year around production may be possible

The project started by excavating an area 30 X 48 dug to a 4 foot depth, which the high tunnel would be built over. The excavator separated the topsoil and the sand subsoil. Since the ground will often freeze to a depth of 6 ft, the bottom of the hole and the bottom 2' of the sides were lined with 2" Styrofoam board insulation, on the top 2' of the sides, 4" thick insulation was used. This insulation at the bottom of the excavation was covered with 1 foot of course sand, then one layer of 4" corrugated plastic drain tile was put over the sand (Figure 1). After covering the tile with 8-12 inches of sand, a second layer of drain tile was installed above the first line, with the lines perpendicular to the first line. This line was covered with sandy subsoil. The corrugation in the tile increased the surface contact between soil and tile so that there is 8' of surface area for every 5 linear feet of tile. On top of the sand about 18 inches of top soil was put in. it is important that course sand is used around the top of drain tiles so that heat can rise quickly. The drain tile is not perforated (It does not have any holes in it) A fan pumps air from the soil through the solar panels. The fan is controlled by a thermostat, which turns the fan on when the temperature in the solar panel reaches 125°F, and turns off when the temperature in the solar panel drops below 85°F.

Figure 1. The lowest layer of tile line with the traditional high tunnel in the back ground.

Figure 2. Solar panels on the south and east side of the high tunnel.

Growing Degree Days (GDD) in the heated high tunnel was a third higher than outside, (Table 2). The heated high tunnel provided more GDD (base 50) during the critical months of March and April, when the heated high tunnel had a third more GDD than the traditional high tunnel. By the middle of summer, the GDD in the two high tunnels were roughly the same each month.

The GDD only partially explains why tomatoes were harvested from the heated high tunnel six weeks before the traditional high tunnel. Warm soil temperatures are critical for proper growth in tomatoes and cucumbers. The soil temperature in the heated high tunnel reached 50°F on March 6, and stayed above 50°F every night after March 15,, while the traditional high tunnel did not reach warm soil temperatures until mid to latter April.

Table 2: Temperature and growing degree days (Base 50) for the 2009 growing season.

Month	Outside		Heated High Tunnel		Traditional High Tunnel	
	Mean Air Temp (°F)	GDD	Mean Air Temp (°F)	GDD	Mean Air Temp (°F)	GDD
March	25.3	4	51.6	221	36.8	157
April	42.5	69	63.4	404	54.6	319
May	55.2	243	65.9	485	63.3	445
June	64	432	68.6	557	67.9	526
July	67.3	497	68.8	581	69.2	549
August	66	494	67.0	526	67.2	534
September	63	387	64.6	408	64.5	415
Total		**2,072**		**3,096**		**2,869**

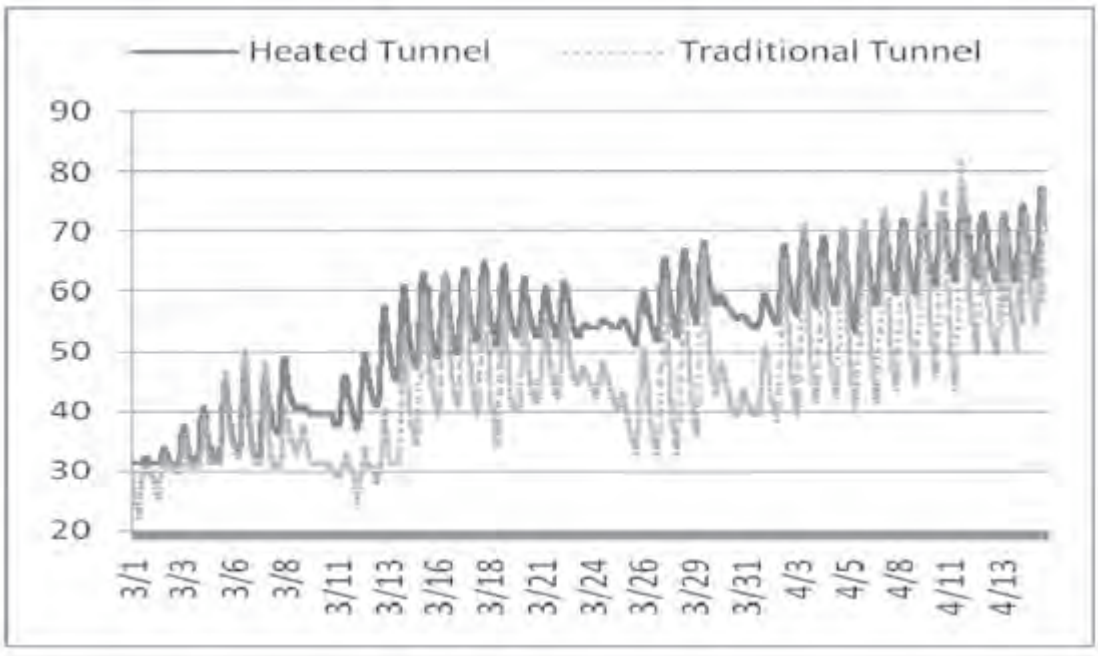

Figure 4. Soil temperature at 2" in the heated and traditional high tunnels.

For more on high tunnels, including our High tunnel Manual; check out the University of Minnesota High Tunnel Web Site www.hightunnels.cfans.umn.edu

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