A Simple Method of Soil Heating that Improves Earliness and Yield of Greenhouse Tomatoes

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Soil heating may increase yield and quality of greenhouse tomatoes, but it is not a standard practice in Connecticut (1), where only the air is heated. Typically, heating commences a few days before transplant of the tomato seedlings early in the spring. Under these conditions the soil may be cooler than the temperature that is optimal for growth. This may slow ripening or decrease yield later in the season, even after the soil is warm (2). When tomatoes are grown hydroponically, heating the nutrient solution to 70° or 80°F improves vegetative growth and increases yield (3).

The most common way to heat the soil is to circulate hot water through tubes in the soil (4) or to use electric heating cables in the soil. Such methods are a substantial and expensive modification of the typical greenhouse, requiring an additional heating system. Here, we describe a simpler method for heating soil that uses the same forced air furnace which is used to heat the air. The only modification to the greenhouse was burial of drainage pipes underneath the raised beds. Heating the soil in this manner increased the yield and the quality of tomatoes produced in the greenhouse in the spring.

The Experiment

The experiment was conducted at Malerba's Farm, Norwich, CT, in a single 25 x 96 foot hoop house covered with a double

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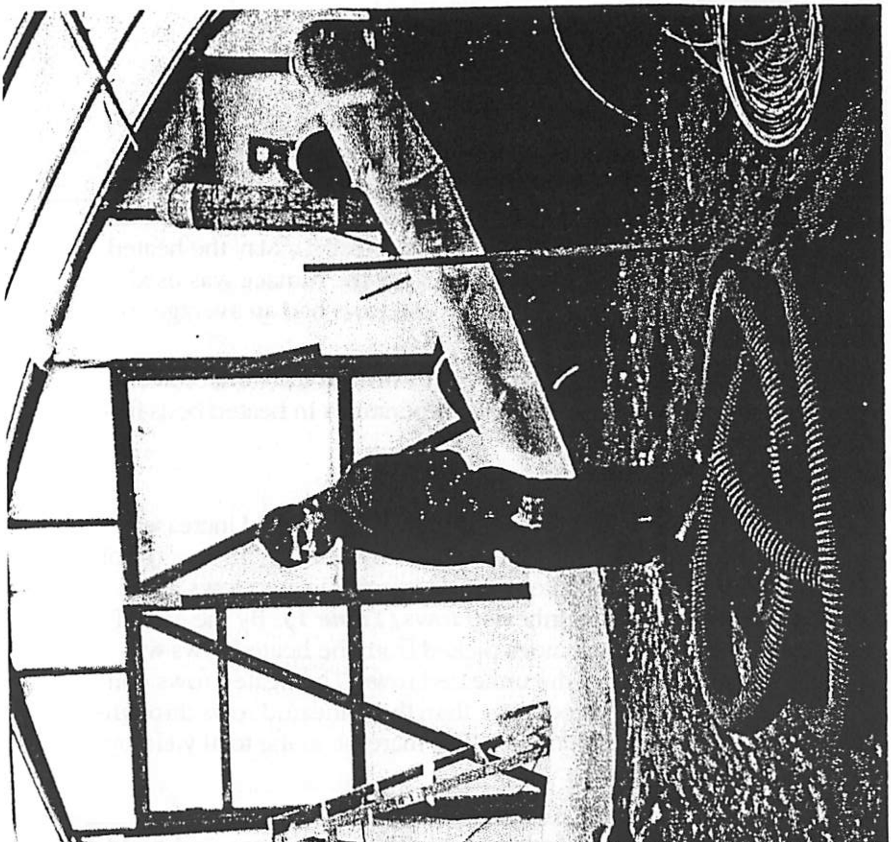
layer of 6-mil polyethylene film. The house was heated by a 300,000 BTU oil-fired forced-air heater located in the south-west corner of the house. The soil was formed into raised beds that were arranged along the south-north axis of the house. Beds were six inches high by three feet wide covered with black polyethylene. Two four-inch diameter black polyethylene corrugated drain pipes were buried 12 inches deep and two feet apart running the entire length under each of the two heated beds. The unheated beds had no drain pipe. The furnace was activated by a thermostat if the air in the greenhouse cooled below 58°F. The air flow through the drain pipes was controlled by constriction of a 12-inch diameter polyethylene distribution manifold that was attached to one of the furnace vents ***(Figure 1)***. The heated air was exhausted from the drain pipes into the north end of the greenhouse.

Beds were planted with a double row of either JetStar (Harris Moran, Rochester, NY), or Buffalo (Stokes, Buffalo, NY). On 21 March, the tomato seedlings were transplanted into the beds, and heating of the soil and the air began. Plants were pruned to a single stem and supported by string. Plants were watered by drip irrigation with a complete nutrient solution (Peters 15-16-17). The concentration was increased from 50 ppm N shortly after planting to 200 ppm during fruit production. Fruit was picked at two- to four-day intervals. Fruit picked from each bed were graded and weighed. Total fruit weight and weight of number one fruit were recorded. The accumulated yield and yield of number ones were calculated as well as the weight fraction of number one fruit. The effects of soil heating, cultivar and bed location were determined through statistical analysis.

Temperatures

Soil temperatures were measured at a four-inch depth at 8:00 a.m., daily for the first few days, then at weekly intervals. The soil temperature was 58°F at planting. The soil in the



heated rows warmed to 66°F in one day and 68°F in one week. The soil in the unheated rows was 58°F one day after planting and 59°F one week later. In April, the soil in the heated rows averaged 69°F, and in the unheated rows 60°F for the first week and 62°F for the rest of April. In May the heated rows cooled from 68° to 66°F because the furnace was used much less for heating. The unheated rows had an average soil temperature of 64°F in May.

Soil temperatures in heated beds nearest the furnace average 3° to 5°F higher than soil temperatures in heated beds further from the furnace.

Results

Soil heating decreased the time to ripening and increased the early and total yield of tomatoes. By June 11, an average of one fruit had been picked per plant in the heated rows, three days earlier than the unheated rows ***(Table 1)***. By the end of June, the yield of tomatoes picked from the heated rows was 14% more than from the unheated rows. The heated rows continued to be more productive than the unheated rows throughout the season, resulting in a 24% increase in the total yield by the end of August.

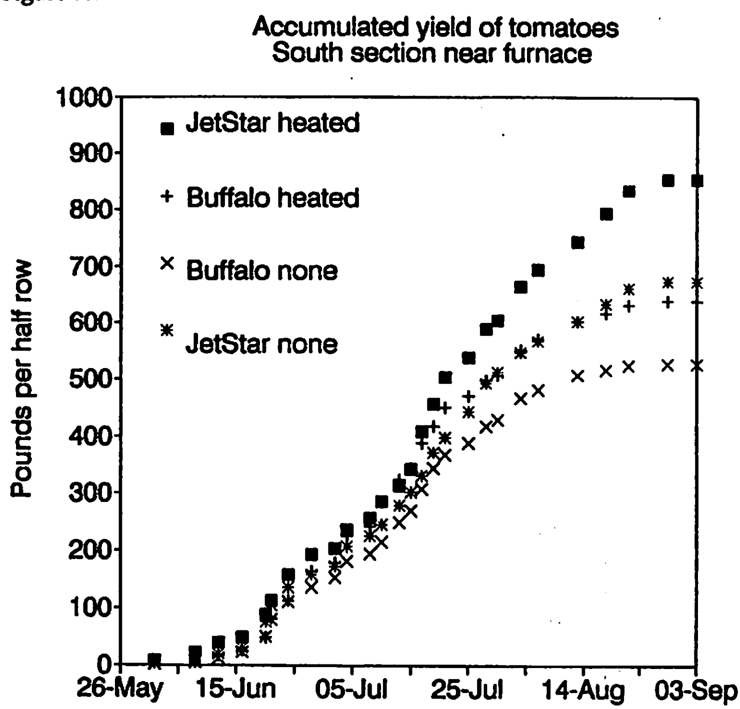
Table 1. Effect of heating the soil on earliness and yield of greenhouse tomatoes grown in raised beds.

Factor	*Date of First Ripe Fruit*	*Early Yield by 1 July*	*Total Yield by 1 Sept*	*Weight Fractions Number Ones by 1 July*	*Weight Fractions Number Ones by 1 Sept*
		(lbs/40 plants)		*w/w%*	*w/w%*
Heated	6/11	166	706	0.62	0.82
Unheated	6/14	144	579	0.66	0.78
	**	***	***	NS	**
Buffalo	6/15	141	553	0.66	0.83
JetStar	6/10	168	732	0.62	0.77
	***	***	***	*	***
North	6/13	147	611	0.64	0.81
South	6/12	163	674	0.64	0.79
	NS	**	**	NS	NS

*, **, ***, Differences significant at 5%, 1% and 0.1% levels, respectively, according to analysis of variance due to soil heating, cultivar and location, with no interaction between these factors.

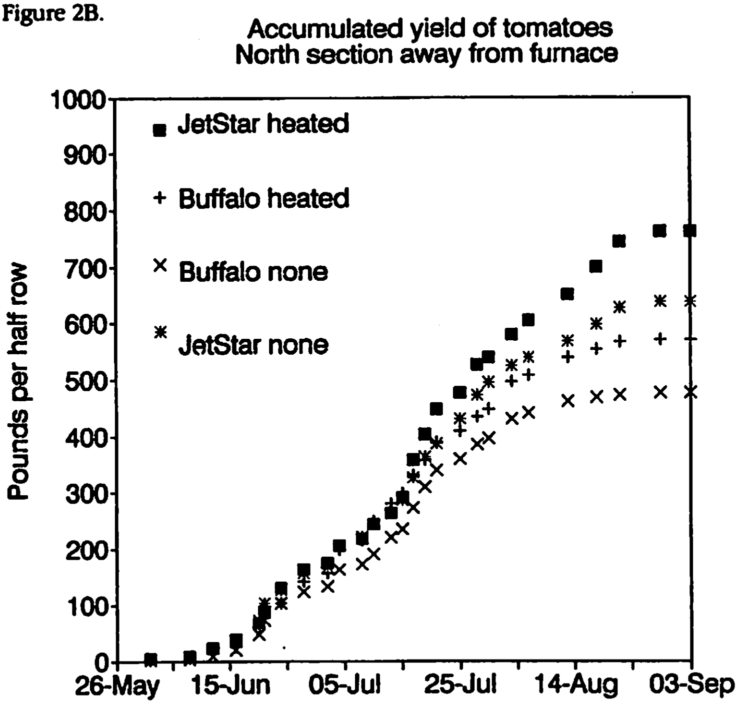
Yields were also influenced by cultivar and by position in the house. JetStar yielded more than Buffalo throughout the season and continued producing in August when production from Buffalo declined. Yields of both JetStar and Buffalo increased with soil heating, but for JetStar, this difference between heated and unheated rows was small until mid July. The difference in yield between heated and unheated rows was greatest in the south half of the greenhouse, near the furnace ***(Figure 2A)***. However, even in the north half, where the measured soil temperatures differed less than in the south half of each row, the heated rows yielded significantly more tomatoes by the end of the season ***(Figure 2B)***. The faster production in the north half occurred primarily after mid-July.

Figure 2A.



Throughout the season, heated rows produced more fruit rated as number ones than did unheated rows. Overall, 82% of the weight fraction of tomatoes picked from the heated rows was number one, compared to 78% for the unheated rows. Buffalo produced higher quality tomatoes than JetStar, but the

Figure 2B.



difference in quality between heated and unheated rows was less for Buffalo than JetStar.

Conclusion

In conclusion, a simple system using hot air from a forced air furnace rapidly heated the soil of raised beds used to grow tomatoes in a greenhouse in the spring in Connecticut. The warmer soil temperatures resulted in earlier ripening and greater yields, both within a few weeks of the start of production and throughout the season.

References

1. Boulton, E.L. ed. 1991. *New England Vegetable Production Recommendations*. Cooperative Extension Service. pp. 68-70.

2. Trudel, M.J. and A. Gosselin. 1982. Influence of soil temperature in greenhouse tomato production. *Hortscience* 17:928-929.

3. Graves, C.J. 1983. The nutrient film technique. *Horticultural Reviews* 5:1-44.

4. Elwell, D.L. et al. 1985. *Soil heating using subsurface pipes. A decade of research results at OSU/OARDC.* Res. Bull. 1175, OSU/OARDC, Wooster, OH, 46 pp.

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