Division of Marketing
Agricultural Development and Diversification (ADD) Program

1998 Grant Final Report

Grant Number 13051

Grant Title Earth Tube System for Greenhouse Heating and Cooling

Amount Awarded $6,390.00

Name Suzanne Baker

Organization Rush Creek Growers
Spring Valley

E-Mail rushgrow@svtel.net

WEB

Department Contact: DATCP - Marketing - ADD Grants
PO Box 8911 Madison, WI 53708-8911
Tel: (608)224-5136
http://datcp.state.wi.us

Earth Tube System for Greenhouse Heating and Cooling

Final Report

Submitted by Suzanne K. Baker
Rush Creek Growers
W4727 770th Ave.
Spring Valley, Wi 54767

The intent of the Earth Tube System (ETS) for greenhouse heating and cooling is to investigate the feasibility of using a simple earth tube geothermal heating and cooling system to lower the consumption of fossil fuels in a greenhouse setting.

Such a heating system might allow Wisconsin greenhouse growers to produce winter crops more profitably or allow production of crops not previously considered profitable. The "low-tech" nature of the system lends itself to many different sizes of businesses. The system also has a cooling benefit that improves the quality of crops grown in warmer months in the greenhouse.

The system of tubes buried in the earth uses the earth's heat to warm air. The air is drawn slowly through the tubes by a fan that then delivers it to the greenhouse interior and distributes the air evenly where it can be further warmed or cooled using conventional heating methods.

In the coldest periods of the heating season, we found that even the earth tempered air was too cold to be injected into the greenhouse atmosphere as some of our crops needed to be grown fairly warm. However, depending on the crops being grown, the system may be suitable. For example, a crop that grows best at 40 degrees F could benefit from the use of this system more hours per day than a crop that requires 55 degree F nights and 68 degree F days.

This grower's experience with the system leads her to think that the ETS would be ideal for very cool crops that would benefit from lots of fresh air. Some examples would be salad greens, spinach, certain cut flowers or overwintering perennials.

Indeed, the greatest benefit derived from the system in our situation at Rush Creek Growers continues to be the ability to introduce fresh, dry air that has been tempered by the earth into our warm, overly humid greenhouses in the coldest part of the year. During these periods our other forms of ventilation (ie roof venting, roll-up walls) are too cold for the crops being grown. This air is certain to be helpful in the prevention of bacterial and fungal diseases thereby increasing the quality of crops grown and lowering the cost of pest control whether biological or conventional methods are employed. These costs are hard to quantify. Our inquiry did not address such questions as how much more loss would have been experienced without the benefit of this system and how much more would we spend on pest controls.

The main focus of our inquiry was to analyze the air temperature change from the outdoor air inlet to the outlet inside the greenhouse. A temperature data recorder was placed in each end of the tubing. The sensing device was dropped down into the tube 4-6 feet to eliminate the possibility of heated greenhouse air affecting the outlet sensor. The data loggers recorded the temperature once each hour over the period of 6 months. See Summary Table 1 on following page.

TABLE 1 - Temperature Variation at Earth Tube Inlet and Outlet Points

temperature in degrees F

Date	Time	Inlet (outside)	Outlet (in greenhouse)	Difference
12/27	6:00 am	12	39	+25
	10:00 am	7	48	+41
	3:00 pm	11	46	+35
12/28	6:00 am	29	46	+35
	10:00 am	35	48	+14
	3:00 pm	35	49	+15
2/18	3:00 pm	27	55	+28
2/21	3:00 pm	41	58	+17
3/21	6:00 am	36	46	+10
	10:00 am	43	53	+10
	3:00 pm	47	54	+10
4/21	6:00 am	33	53	+20
	10:00 am	45	61	+16
	3:00 pm	48	61	+13
5/18	6:00 am	44	55	+10
	10:00 am	56	65	+9
	3:00 pm	56	69	+12
7/21	10:00 am	69	69	+0
	3:00 pm	72	74	+2
8/21	10:00 am	64	63	-1
	3:00 pm	64	71	+6
Average				**+14**

The grower's interpretation of the data finds consistent warming of the air. The average increase in temperature was 14 degrees. The actual warming decreased in the warmer months but the air introduced is still cooler than the ambient daytime summer greenhouse temperature. In the coldest hours of coldest days we deemed the incoming air too cold to be introduced into our greenhouse and decided we had to turn the system off during those coldest nights and cloudy days. On cold sunny days, however, we welcomed the influx of cool dry air into the growing environment.

Given that the system works in theory, one must explore the economics. This provokes another series of questions:

- What would your cost of construction be?
- What is the payback time in or savings in fuel?
- What if the same dollar amount were applied to other energy saving measures such as more efficient furnaces or heat curtains?
- What are the dollar values of the other benefits of the system (ie increased quality or reduced costs of pest control)?

The scope of our experiment did not allow us to answer all these questions but these factors should be considered when undertaking such a system.

While our data logging devices show that the air was warmed as it was pulled through the tubes, it is unclear if the benefits of the system really make it a sound investment. As greenhouse technology improves in the area of energy conservation there may be other systems that would prove to be a better investment. Heat curtains may be one such example.

We can simply outline our costs for our system for use in such an analysis.

TABLE 2 - Materials Cost of ETS - November 1998

Materials	**Cost**
Tubes	$2372.00
Tape, Joints	$8.00
Level	$277.00
Ductwork	$300.00
Tube Axial Fan	$515.00
Poly Duct	$50.00
5 Gal Drums	$20.00
Structures	$238.00
Data recorder	$292.00
	$4072.00

TABLE 2A - Labor Cost of ETS - November 1998

Tasks	**# Hours**	**Total cost @ $16.00/hr.**
Procurement of supplies	15	$240
Hand leveling & rock removal	12	$192
Tube laying	40	$640
Hand Tamping	60	$960
Loader operation	6	$96
Finishing tube & manifold	16	$256
Building surface structures	16	$256
Fan Installation	8	$128
Ductwork	8	$128
Data recording	12	$192
Total	**193 hrs**	**$3088**

TABLE 2b - Subcontractor Costs

Equipment	Hours	Cost
Bulldozer	3.5	$148.75
Backhoe	1.75	$350.00
Loader	16	$350.00
Total	**21.25**	**$848.75**

TABLE 2d - Cost Totals for ETS system - November 1998

Item	Cost
Materials	$4072.00
Labor	$3088.00
Equipment	$848.75
TOTAL	**$8008.75**

Cautionary Notes on design:

a) Soil requirements

This system requires deep soil. Trenches ideally should be dug 6-7 ft. deep to take advantage of the earth's heat. Rocks encountered in our soil created problems as we needed to adjust the slope of the bottom of the trench. Our system lies 6' deep because we encountered bedrock at that depth. Soil type is also a consideration. Small particles will transmit hear more readily than larger ones so a clay or silt soil will work better than sand. The soil must be tamped around the tubes to create good air to soil contact.

b) Condensation

Remember that moisture will condense out or cool air as it warms. The tubes must drain properly and provisions must be made to drain the condensate. If gravity is not an option then a sump pump system must be installed at one end of the system or the other.

c) Fan Selection

The fan installed to draw air through the ETS must be capable of operating under the static pressure that develops in the long tubes. It must draw the air slowly to allow for heat transfer. Our fan is a tubaxial model designed to move 1270 to 2400 cfm .125" to .5"SP. Care must also be taken to make the manifolds and ductwork in a way that does not restrict air flow. Ours is 30" square.

Summary:

The ETS is a possible source of supplemental heat for the greenhouse industry. It makes use of the earth's natural heat holding capacity. Benefits include: the use of a sustainable heat source to reduce dependency on fossil fuels; earth tempered air for cooling and ventilating purposes thereby reducing pest control problems and crop loss. A cost benefit analysis must be performed to determine if this is the appropriate technology for a particular grower and their grower.

Recommended Reading:

Midwest Plan Service. (Dec 1984) "Earth Tube Heat Exchange Systems". *Ag Engineers Digest*. (Ames: Iowa State University). ISBN 0-89373-064-5

National Food Energy Council. *Ag Technical Brief.*
AT-126 Earth Tube Heat Exchange/Ventilation Systems. Columbia, MO