Sustainable Low-Cost Heating for Season Extension Structures

Final Report for FS07-214

Project Type: Farmer/Rancher
Funds awarded in 2007: $14,928.00
Projected End Date: 12/31/2007
Region: Southern
State: Tennessee
Principal Investigator:

Steve Hodges
Clinch Appalachian Farm Enterprises

Project Information

Abstract:

SARE Producer Grant Final Report
Clinch Appalachian Farm Enterprises (CAFÉ)
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1. Project Activities:
CAFÉ held two workshops demonstrating various sustainable alternatives, to traditional methods of heating season extension structures. The first workshop was held October 2007 and the second January 2009. The first workshop focused on the transferring of heat from compost systems into greenhouses/hoop houses. Workshop presenter was Will Allen from Growing Power in Milwaukee, Wisconsin; 22 people attended the daylong workshop. While the original intention was to bring Will Allen back in 2008 for a second workshop and coaching session on several farms, we found that participants on only one farm actually continued using the composting method to heat its hoophouse, so project staff decided instead to hold a second workshop highlighting several other methods that might gain broader acceptance and application among growers. Given this change in plans, it took until January 2009 to hold the second workshop with several qualified presenters. The second workshop showcased season extension heating options such as: using heat sinks, constructing low tunnels within high tunnels, subterranean heating and cooling systems, installing low tech geothermal, heating stoves which burn used motor oil, developing a system of using foam between double layer of polyethylene plastic and several other experimental options. The second workshop was moderated by Dr. Annette Wszelaki, Vegetable Extension Specialist and Assistant Professor in the Plant Sciences Department of the University of Tennessee; workshop presenters included Anthony Flaccavento, Executive Director of Appalachian Sustainable Development; Tamara McNaughton, Executive Director of Appalachian Native Plants; and Yonatan Strauck, a Graduate Student at Appalachian State University. At this second workshop 25 people attended. Both workshops resulted in several attendees joining CAFÉ as members.

CAFÉ members were given the opportunity to participate in a monitoring project after the completion of these workshops. Following the January workshop described above, six CAFÉ members who had participated in the workshop chose six different low-cost heating options to monitor for a three to four week time period during February and March 2009. Each participant kept detailed records of cost, time, construction, and environmental conditions. Each were loaned two or three temperature/relative humidity data loggers (HOBO) in order to more efficiently record data. After the completion of the study, they each analyzed their own data and records, wrote a report with findings, and presented the reports at a Farm/Field Day held March 7, 2009. The Farm/Field Day showcased two of the six farms and heating systems which participated in the monitoring project, and reports were presented at the Farm/Field Day on the results from all of the six farms participating. Most analysis was concentrated on early morning temperatures and the effectiveness of the chosen heating method for raising these temperatures in the hoophouse. Temperatures were the lowest at that time, and there were not as many other factors to consider such as hours of daylight and angle of the sun etc. Because of the change in the project plan as noted above, there was not time to measure the impact of the chosen heating methods on production and sale of produce in the greenhouses for the purpose of this report, but CAFÉ does intend to note these impacts in the coming months.

2. Results:

Monitoring project #1: Steve and Diantha Hodges measured temperature and relative humidity inside and outside of their 16x24ft (single sheet greenhouse plastic) hoop house for 7days. On day 8 of monitoring they added a monitor inside of an 8ft low tunnel inside of the hoop house. The temperature and relative humidity was then monitored in all three locations for 18 days. Data shows that the temperature in the hoop house stayed an average of 5.5 degrees (F) warmer (range: 4.2 to 7.3 degrees) than the temperature outside. Data showed that the temperature in the low tunnel stayed an additional (average) 4.9 degrees (F) warmer than the temperature in the hoop house. We can conclude that low tunnels within hoop houses do provide a substantial heat increase with very little added cost. The challenge seems to be keeping adequate ventilation within the hoop house/low-tunnel during the day, in order to reduce heat and rh. It was found that on sunny or humid days the humidity and temperature in the low-tunnel rose very high, very quickly.

Monitoring project #2: Hugh and Jan Price measured temperature and relative humidity inside a low tunnel, which was within a low hoop house (8ftx16ft, but only 4.5ft.high, covered with a single sheet greenhouse plastic and med. wt. row cover). Temperature and relative humidity was measured outside as well as in the hoop house and the low tunnel for the full 28 days. Data shows that the temperature in the hoop house stayed an average of 4.3 degrees (F) warmer (range: 2.5 to 7.0 degrees) than the temperature outside. Data showed that the temperature in the low tunnel stayed an additional (average) 1.5 degrees (F) warmer (range: .75 to 2.7 degrees) than the temperature in the hoop house. We can conclude that low tunnels within low hoop houses do provide a moderate heat increase with very little added cost. The difference between project #1 and this project is that this hoop house is much smaller, especially in height. The challenge seems to be keeping adequate ventilation during the day (when sunny) within the hoop house/low-tunnel, in order to reduce heat and rh. It was found that on sunny or humid days the humidity and temperature in the low-tunnel rose very high, very quickly.

Monitoring project #3: Tom Henry measured temperature and relative humidity inside and outside of an 18x50ft (single sheet greenhouse plastic) hoop house for 30 days. A 4ftx5ftx4ft high compost pile, centered on north interior wall was built on day 1 of monitoring. Interior heating of compost should have begun about 7 days after construct. Unfortunately the end walls were less than airtight, and any wind may have affected the outcome /advantage. Due to the end walls being unsecured and the fact that the compost did not adequately heat, we have no conclusions.

Monitoring project #4: Lisa Long measured temperature and relative humidity inside and outside of a 12x14ft (single sheet greenhouse plastic) hoop house for 28 days. On day #14, tightly baled leaves were stacked along the north wall and northwest corner of the hoop house. These were stacked to a height of four and one half feet. Data from days #1-#14 shows that the temperature in the hoop house stayed an average of 3.2 degrees (F) warmer than the temperature outside. Data from day#15-#28 showed that the temperature in the hoop house stayed an average of 2.5 degrees (F) warmer than the temperature the outside. We can conclude, materials such as leaves (insulation), on the north side of a season extension structure does not provide any significant increase in indoor air temperatures. It may be that it stops reflection of light from the north wall. It would be interesting to study soil temperature differences in this study.

Monitoring project #5: Elizabeth Malayter measured temperature and relative humidity inside and outside of a 30x100ft hoop house for 28 days. On day #15, a second layer of plastic was installed. Due to the presence of several holes in the first layer of plastic, they were unable to use the inflation blower fan to create a layer of air between the plastic. There was also a problem with the zippers at the end walls not holding. This allowed too much ventilation indoors. Data from days #1-#14 is very similar to data after the second layer of plastic was added days#15-#28. We can conclude that the results are not accurate due to excess ventilation.

Monitoring project #6: Travis and Renee Johnson measured temperature and relative humidity inside and outside of their 13x60ft (single sheet 4mil, opaque plastic) hoop house for 18 days. . Their home is approx. 5ft. underground, below the hoop house. A woodstove is used for heating the underground house. The woodstove pipe comes through the ceiling of the underground home, through the earthen floor of the hoop house and straight up through the ceiling (west end) of the hoop house. During the first 8 days, 40ft. of the hoop house was monitored without enclosure of their woodstove pipe. On day #9-#18 the 40ft was monitored with enclosure of the woodstove pipe, to radiate heat. Data shows that the temperature in the hoop house stayed an average of 3.25 degrees (F) warmer than the temperature outside during the first half of the study. Data showed that the temperature in the hoop house stayed an average of 8.50 degrees (F) warmer than outside during the last half of the study.

As one might expect, based on the data, the heat from the stove pipe was very successful at heating this hoop house. It seems that with the heat from the stovepipe, the relative humidity usually was only 1-2 degrees higher than outdoors. We realize very few people live underground, but this system might be applied to almost any dwelling which uses a wood stove for heat. A home, garage or shed heated with a wood stove which had an attached greenhouse/hoop house could run the pipe horizontal into the greenhouse and then out one end of the hoop house or horizontal and then vertical through ceiling of greenhouse. The Johnsons intend on extending the stovepipe horizontally along hoop house at ground level next fall, for more even heating.

3. Future Work:

If we would do the project again, we would have chosen an organic farm on which to hold the first (composting) workshop; by doing that we might have gotten more follow-up data. Also, during the on-farm experiment phase of the project where several different heating methods were monitored, we would monitor soil temperature fluctuation and not just air temperature fluctuation. And we would re-test some of the same systems under more carefully controlled situations than our growers practiced this time, with greater attention to air leakage from hoophouses, optimally prepared compost, etc.

4. Adoption:
Based on what we learned and experienced, our growers will (1) make use of low tunnels within high tunnels as one of the most effective and least expensive ways of adding additional temperature protection/reducing heating costs in season extension structures. They will also (2) increase their attention to adequate ventilation of season extension structures, given the high humidity measured during the experimentation process. Though we did not find that composting was an effective method of reducing heating cost due to the amount of space it took up in the hoophouses, most of our growers will (3) continue composting as a way of creating valuable and inexpensive soil amendment. Finally several of the growers have said they will (4) continue using the data loggers ("Hobos") to measure temperature and relative humidity inside and outside their season extension structures and to continue experimenting with more carefully controlled situations using the heating methods studied, as well as various other ways of creating the optimum temperature and humidity in the structure for the least cost.

5. Outreach:
Outreach activities for this project included a Farm Field Day reporting on the results of the project, as well as a written flyer and a PowerPoint slide show summarizing the project and its conclusions. The Farm Field Day, as described above, was conducted at two of the six farms participating in the experiments monitoring different low-cost heating methods for hoophouses; twelve people attended the Farm Field Day. The written flyer and PowerPoint slide show were made available on the Farm to Institution website of Jubilee Project which will be linked to a new CAFÉ website under construction. The written flyer was emailed with a brief explanation of the project and an invitation to view the website and its materials, to about 150 persons including 83 growers and extension agents from the east Tennessee region who are on the Jubilee Farm to School mailing list, and to about 65 attendees to the Tennessee state meeting at the 2009 Southern SAWG Conference. The conclusions of the project will be shared at future workshops of Southern SAWG and as available, other venues.

6. Summary:
Clinch Appalachian Farm Enterprises set out to find low-cost of ways of heating season extension structures that would be an alternative to traditional ways which are a barrier for some small-scale farmers to adopting season extension methods. Though 22 farmers attended a workshop on using the heat from composting, an initial focus on this method did not result in significant adoption of the method by farmers. As a result, the project changed to focus on a variety of other methods and a workshop presenting information on these methods was held in January 2009 and 25 people attended. Based on the presentations, six growers participating in that workshop agreed to monitor the impact of six different promising applications of alternative heating methods, using data recorders to record temperature and relative humidity both before and during use of the heating methods. The most significant results in raising low outside temperatures was found by constructing low tunnels within high tunnels. The growers also found that the significant retention of relative humidity in the season extension structures underscore the importance of ventilating them even during the winter when high internal temperatures allow this. The results of the project were shared with local growers through a Field Day, through email, and through information on the Jubilee Project Farm-to-School Website (www.jubileeproject.holston.org). The results were also shared with the list

of Tennessee participants at the 2009 Southern SAWG Conference, and will be shared at future workshops at SSAWG and other venues.

Research

Participation Summary