COVEYOU FARMS LLC

Irrigation Water Conservation and Supplemental Solar Heating for Small Farm Season Extension Greenhouse Production

Conservation Innovation Grant Final Report

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Executive Summary

This project to demonstrate rainwater collection, reuse and a heat storage system for greenhouse applications was coordinated by Coveyou Farms LLC. The project was successful in demonstrating the on farm rainwater collection system that has heat mass storage capability. The technologies used in this project are commercially proven methodologies that are applied in an innovative fashion to benefit small farm applications with direct transferability and scalability to larger farm operations. Improving water conservation through the use of new technologies was the focus of this demonstration project.

The Goals of the project were to:

- Eliminate the need for deep well water or surface pond pumps for greenhouse irrigation through the use of roof runoff water collection into a below ground reservoir.
- Demonstrate the use of new economical low evaporation bottom watering irrigation mating and other drip irrigation and fertigation systems in a greenhouse environment to conserve water and to decrease humidity levels and venting of warm humid air from the greenhouse during production.
- Demonstrate that solar renewable energy can decrease the amount of fossil fuel needed to heat irrigation water in a greenhouse.
- Adapt existing innovative underground storage tank technologies used to collect water runoff in commercial applications to agricultural farm use.
- Apply existing solar heating systems (similar to pool heating systems) to an agricultural use to demonstrate the reuse of an irrigation reservoir as a thermal storage mechanism for solar energy and application of that energy at night.

- Collect data and evaluate the effectiveness, utility, affordability, usability and overall benefits of this water and energy conservation system over a two year period in a commercial growing environment.
- Document the design, installation, operation and effectiveness of the project in a manner that it can be transferred and used by others.

The details behind many of these project goals were shared at the Northern Michigan Small Farm Conference attended by several hundred regional farmers as well as through a USDA extension bus tour field trip allowing farmers from around the state and region to hear first-hand details of these systems. We view that the main benefactor of this type of project are the fellow farmers who can observe, learn, and apply features of these systems to their own operation. It is these technologies that will allow farmers to enhance their production systems and improve their bottom line.

This project was completed within the budget planned and ongoing improvements to the systems will be funded from our farm resources. The timeline was stretched out to allow the activities to get completed. There were some hurdles due to utility company service relocation and other obstacles that stretched out our timeline; however, the real challenge was being able to make the progress desired on the project during the very busy growing season.

On the whole we view this project demonstrated a sustainable method of lowering the operating costs as well as conserving rainwater for reuse in a plant growing system. This technology is an integral part of our operation and we believe others who embrace this technology will value what it brings to the sustainability of small local produce farms.

Introduction

This project to demonstrate a rainwater collection, reuse and heat storage system was carried out by Coveyou Farms LLC of Petoskey, Michigan. Coveyou Farms LLC is a 140 year old family farm in the northern portion of Michigan's Lower Peninsula that focuses on growing produce, flowers and other items for sale to the local and regional community. This project was funded solely through the resources of Coveyou Farms LLC and the USDA CIG grant program. The results and findings of the demonstration project were shared with regional and state farmers through the Northern Michigan Small Farm Conference, National Value Added Conference and through on farm tours with USDA extension coordination.

The purpose of this project was to design, install, evaluate and document a rainwater collection and water conserving irrigation system in an on-farm greenhouse that also uses renewable energy to reduce the amount of fossil fuel needed to heat the growing space and irrigation water. Furthermore, new irrigation water conserving bottom root zone matting, drip irrigation and fertigation systems were installed and evaluated with the focus on small farm applications.

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- Demonstrate the use of new economical low evaporation bottom watering irrigation mating and other drip irrigation and fertigation systems in a greenhouse environment to conserve water and to decrease humidity levels and venting of warm humid air from the greenhouse during production.
- Demonstrate that solar renewable energy can decrease the amount of fossil fuel needed to heat irrigation water in a greenhouse.

- Adapt existing innovative underground storage tank technologies used to collect water runoff in commercial applications to agricultural farm use.
- Apply existing solar heating systems (similar to pool heating systems) to an agricultural use to demonstrate the reuse of an irrigation reservoir as a thermal storage mechanism for solar energy and application of that energy at night.
- Collect data and evaluate the effectiveness, utility, affordability, usability and overall benefits of this water and energy conservation system over a two year period in a commercial growing environment.
- Document the design, installation, operation and effectiveness of the project in a manner that it can be transferred and used by others.

Project Background:

Small and midsized farms across America are transitioning to grow vegetable and horticultural crops for local sales including the direct marketing to the public as a means of increasing revenue and ultimately sustaining family farms. A challenge in growing food and floral products is the need in many northern portions of the country to use cold frames or greenhouses to extend the natural growing season allowing plants to be started earlier in the spring or protecting plants from frost in the fall. Similarly, the horticultural industry grows extensively in large and small greenhouses across the country. Water and heat are two of the fundamental elements required in these operations and both are desired by growers to be conserved due to both economic and environmental reasons. Farmers also need ways to access water in early spring when ice and cold temperatures prohibit the use of surface irrigation ponds. Pumping from deep wells is presently the only option. This project demonstrated that new innovative technologies do exist and can be applied to farmers who need the season extension protection of greenhouses to make their farms sustainable in supporting local sales of vegetable and horticultural products. This project will demonstrate a rainwater collection system that stores water in a new low cost and innovative underground reservoir below the greenhouse where the water will be available for greenhouse irrigation, field irrigation or even sprayer filling throughout the year. Furthermore, the rainwater reservoir will also be used as a heat storage thermal mass to store solar heat energy collected during the day for use during the night where it will be transferred to the greenhouse growing space to decrease the amount of fossil fuel heat required. The large water reservoir has additional benefits throughout the summer where its frequently replenished supply from rainfall can also be used for small field irrigation and sprayer filling or any other farm needs for water.

Review of Methods

This section will review the details of what was implemented in this project. This project involves the novel use of a roof runoff conservation system to collect rainwater runoff and store this water in an innovative underground flat water reservoir located under the growing area of a greenhouse. The novel flat water reservoir technology is one of the key elements of this project and is increasingly being used by commercial builders and municipalities as a means of storing facility irrigation water and minimizing storm drain runoff. This new but proven reservoir technology has not been applied to agricultural applications from our research when we started this project. The technology is used significantly in Australia. The approximately 12,000 gallon reservoir is assembled below grade allowing it to sit below the floor of a greenhouse which gives it protection from freezing ground temperatures. The reservoir water tank barrier is made of a thick wall (40 mil) flexible poly liner wrapped around a plastic skeleton made of stacked rigid plastic blocks (similar to very strong empty milk crates). The liner is similar to that used in landfills. In our application this reservoir is thermally insulated from the ground with a high R value dense foam board insulation. The backfilled soil holds the structure firmly in place resulting in a structure designed to withstand the pressures from heavy equipment driving over the system. Water from a rooftop rainwater gutter collection system is used to fill this underground reservoir and has inlet filtering and overflow bypass storm surge capabilities designed in. This large water reservoir is physically placed directly underneath a poly covered greenhouse that was built after the tank installation. The reservoir is designed to be at a depth such that any heat that is lost will radiate up through the bottom of the greenhouse thereby providing an added element of efficiency.

An excavated hole in the ground was dug, leveled and compacted to an area 4’ larger than the planned rectangular tank which measures approximately 14’x20’x5’ tall. A 2” layer of pea stone was installed across the area to allow leveling within 1/4”. Insulation was installed on the bottom and sides of the tank since this tank is also intended to be able to hold heat energy for both warmer irrigation water as well as the potential to pull heat out of the tank for heating the root zone of the growing plants within a greenhouse. 4” of rigid poly insulation was layered on top of the pea stone to an area 1’ larger than the tank perimeter. The larger pad on which the tank was built would allow the tank to remain level if any minor shifting took place during construction or backfilling of the hole. A layer of felt was then installed over the insulation to prevent the rubber membrane from getting any tears or punctures from rocks. A single piece of 40mil thick soft rubber membrane was draped over the felt and was followed by a second layer of felt. The plastic frame skeleton that makes up the rectangular box was next individually assembled and put in place. Oxygen barrier pex tubing slots were cut out of the plastic skeleton boxes and four pex tubing runs ran through the box to allow heat transfer into the water within the box. Figure 1.1 shows a picture of the assembly in progress.

Figure 1.1 Water Conservation tank assembly

The entire matrix of skeleton boxes were put in place and then the felt, rubber, felt layering was pulled over the top similar to wrapping a large present. Figure 1.2 shows a picture of the wrapped and completed tank.

Figure 1.2 Completed and wrapped irrigation container prior to backfilling

2” rigid poly insulation board was installed on the sidewalls of the tank and then soil was slowly backfilled all the way around the tank and compacted into place. To be able to gain access to the tank a pressure treated wood subfloor was built on top with a layer of weedmat fabric covering the entire greenhouse floor.

The greenhouse was assembled on over the top of the tank and rainwater harvesting system put in place to capture the rainwater and allow it to be contained in the tank. 4” and 6” plastic PVC piping was used to take water running from the roof system and pipe it through a coarse debris filter and into the tank. A valve was installed to allow bypass of the water out to an overflow dissipation area if the tank is full or we don’t want to have any more water put into the tank. Additionally, if the tank is full and not monitored water will automatically flow into the overflow dissipation area outside of the greenhouse even if the tank valve is open.

Our original plan was to implement solar heating of this irrigation water but as research and time progressed we found that geothermal heating vs. solar was potentially more practical because of our ability to get more heat out of the system when we needed it (March-May) and that we would have to do more work to assure we would not heat the water up too much and melt the plastic components in the hot summer days when we did not need the heat anyway. This evolution in thought came about through a lot of investigation as well as the significant advancements in geothermal heat pumps over the years since this project first started. Adding a geothermal heat pump is beyond the technical and financial scope of this project but is being implemented by Coveyou Farms LLC for growing area root zone heating as a follow on to this project. The greenhouse shown in Figure 1.3 was assembled on top of the water tank after it was installed.

Figure 1.3 Greenhouse on top of watertank

New and innovative bottom watering capillary action mats tested at the University of Florida and now commercially available have also been applied in this project to demonstrate the water conserving nature of this irrigation method to the small farmer. These irrigation mats have been documented to decrease irrigation water consumption by 50% as compared to overhead watering. The mats are constructed similar to a large poly plastic bag with a layer of felt inserted into the middle of the bag. A fine matrix of slits are made in the top surface material of the seam welded bag that allows water to flow through but only when a potted plant exerts enough pressure from sitting on it to make contact with the water loaded felt below. This approach minimizes evaporation of water because sun and wind doesn't pull water out of the bag since the top surface doesn't contact the water holding felt except where the plants are placed. Two or three flat plastic drip lines are run down the length of the bag and allow for a slow filling with water of the felt holding surface. This technology works very well and significantly helps reduce water consumption but also minimizes labor needed to water plants. Most importantly this technology allows plants to grow better through a constant supply of water pulled through the root zone without overhead watering allowing for decreased fungus and mold growth issues. A fertilizer dosing injector was used to supply minerals, chemicals and fertilizers to plants growing on the water mats.

Outreach and Sharing of Results

The results of this demonstration project have been shared in multiple ways. A presentation was given at the yearly Northern Michigan Small Farm Conference in Grayling, MI in January of 2013. This conference brings over 600 small farmers from around the region together. Our presentation on these conservation innovation technologies was standing room only with many rating in the post presentation survey that the material presented was very applicable to their operation and that many replied they would consider using these ideas in their farm practices. The positive responses led the conference committee to ask that we repeat the presentation at the February, 2014 Small Farms Conference where we will update the presentation with the latest improvements and additional work.

The second main outreach activity took place in August of 2012 with a USDA NRCS planned bus tour bringing farmers from around the state and greater Midwest to see innovative farms. This walking tour and first hand being able to answer questions from the many farmers was another good way for people to take away the insight and knowledge developed in this project.

Additionally, an overview of this conservation project was presented at the USDA Value Added National Conference in June of 2012 in Traverse City, MI. This presentation was well received by those in attendance.

In addition to these formal presentations on the technology there have been many individuals who have asked for insight or I have shared what we are doing with conservation innovation technologies on the farm.

Deliverables

This project has three main deliverables.

- **Demonstration that new underground water storage reservoirs currently used in commercial application have benefits in a farm environment to store large quantities of roof runoff rainwater.**

  We view that the design and installation of the water tank described in this project has met the goals of this deliverable.

- **Demonstrate that large irrigation water reservoirs under a greenhouse can be used as an effective thermal mass to eliminate the need for fossil fuel water heaters and decrease the amount of fossil fuels needed to heat the greenhouse growing space.**

  We view that our investigation of the evolution of technology as this project progressed revealed that solar may not be the optimum non fossil fuel for heating large water reservoirs for spring time energy needs. Geothermal high efficiency heat pumps can deliver a significantly higher amount of heat energy during the months when the heat is needed. Additionally, geothermal heat pumps do not have the added challenge of being able to handle the stresses on the system components that solar would during the hot summer days when the heat is not needed. The use of the insulated water reservoir for heat storage is still supported.

- **Demonstrate that new irrigation matting is an effective means of watering and fertilizing plants with minimal evaporation.**

  We view the research, installation and use of the bottom watering mats with dosing fertilizer injectors as successful and very helpful in the production of both vegetable and horticultural flower production.

Findings, Conclusions and Recommendations

This project demonstrated that new water retention tank technologies have real potential to conserve and decrease the water use through deep well pumping on farms. The commercial water storage technologies demonstrated are typically used in commercial construction or road building projects but can be applied to small farm applications. This technology allows the relatively easy approach to storing large volumes of water underground. The tank size can easily be adjusted for any given farms application and with many areas struggling with drought conditions or water rationing these types of technologies that can conserve large volumes of clean rainwater at no cost will have growing merit for small and large farms alike.

Keeping abreast of the evolving commercial technologies and finding ways to apply them to our farm operations will go a long way to improving the environmental and economic character of agriculture.

It is our hope and intention that others in the farming community will be able to benefit from this demonstration project and be able to build upon this work to further the use of this technology and spur the application of others in the future.