Rainwater Harvesting System for Organic Farming

G. Michael Evans, Matthew I. Fernandez, and Ryan J.A. Power

Abstract. A rain water collection system for the Guelph Centre for Urban Organic Farming (GCUOF)has been designed to meet the irrigation demands of the farm 9 out of 10 years. The design uses no municipal services or electrical energy and collects rain water on site using an elevated catchment "funnel" along the southern edge of the farm. Drip irrigation is used to water the crops. Water is stored during the winter months in the greenhouse for irrigation. Best farming practices for water conservation are assumed to be used along with dilligence on the farmer's part. The final cost of the system is estimated to be $26000.

Key words: rainwater harvesting, organic farming, drip irrigation, energy free farming, treadle pump

1 Introduction

The Guelph Centre for Urban Organic Farming (GCUOF) has a two acre site that requires a water supply for irrigation. On the site, there are two areas requiring irrigation. A greenhouse that requires year round irrigation, and a vegetable crop field that requires irrigation from April 1 to October 20 each year; a 29 week period. To provide water for the site, the design utilizes rain water collection.

No municipal services of any kind were to be used, and that water quality must meet standards for irrigation purposes. Relevant criteria included minimizing cost, maximizing rain water collection, and making the design as simple as possible. It is assumed that the GCUOF is using best farming practices, such as mulching and drip irrigation, and that irrigation will only be used when required, and not right after or during a rain event that provides sufficient water. Figure 1 shows the site overview.

2 Design Overview

Rain water collection generally involves water capture, water conveyance, such as piping, water treatment and water storage. In this design, rain water is captured by a $264m^2$ catchment funnel of galvanized steel sheet. Water then runs through a leaf screen at 95 percent collection efficiency, a first flush water treatment device, a mesh filter and into storage tanks.

To provide sufficient water pressure for drip irrigation, an 800 litre pressure tank is included. To get the system to operating pressure, a treadle pump is used. The treadle pump is foot operated and takes no more than 15 minutes for one person to pump. As water is released to the the drip manifolds and drip tubes, the pressure will decrease to a low of 15 PSI, where the system will be turned off by closing a valve. To provide water to the greenhouse, a hose will be connected to the pressure tank, and in-greenhouse water storage barrels will be filled. The greenhouse will be watered by a human using a watering can.

At capacity, the pressure tank discharges the appropriate volume of water at sufficient pressure to irrigate 1/6 of the crop at a time. The crop is divided into 6 sections and is irrigated 6 days a week. The greenhouse, requiring only a fraction of the total demand, was designed to store enough water to last through the winter months. At the end of the growing season the remaining storage is used to fill the greenhouse barrels for winter use.

The main innovation of the design is the introduction of a raised catchment structure located on the south-east edge of the farm that will be nothing more than galvanized steel sheet with supports, beams and posts. The roof is slanted towards the centre of the shelter where a drain empties into a pipe to the storage tanks, providing a catchment area for rain water collection and on-site storage protected from rain and snow.

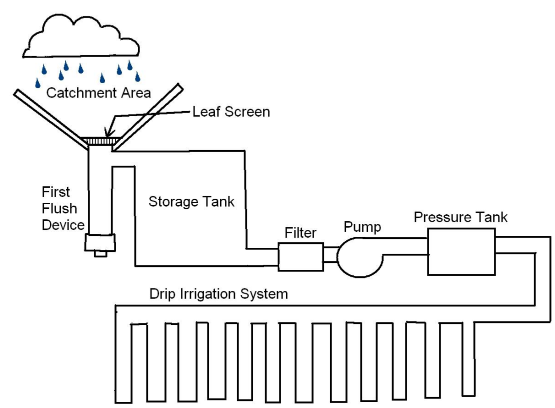

Fig. 1. System layout

3 Detailed Design

3.1 Catchment and Storage

The catchment structure is located on the south-east of the site. The 12m x 22m funnel is constructed of galvanized steel sheet metal and lumber and will capture precipitation through a leaf screen and flush device into 3 storage tanks. The first flush device diverts the first 0.5 mm of rainfall totalling 125 litres for this system. The tanks are connected in series and have an overflow pipe. They can hold a total of $19.1m^3$. The raised catchment doubles as a storage area protected from rain and snow. The greenhouse contains a $2.5m^3$ storage tank that is filled by the pressurized delivery system and serves several purposes. It supplies the needs of the greenhouse during the rainwater harvest season. It is filled before the season ends, and will hold enough water for the entire winter as well as to fill the pressure tank in the spring. Figure 2 below shows the site layout, and Figure 3 is a detail of the catchment.

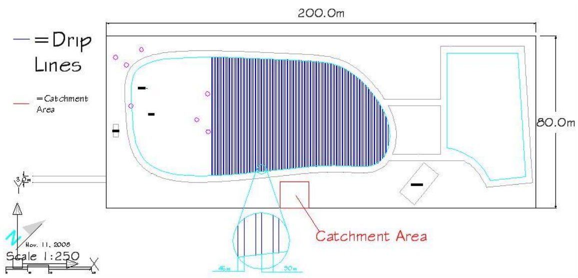

Fig. 2. System diagram

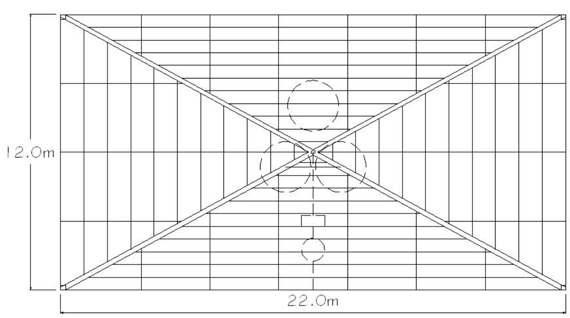

Fig. 3. Catchment

3.2 Pumping System

A treadle pump is used to force water from storage to a pressure tank. To pump the pressure tank from 15 to 20 psi, it is estimated it will take one person 14 minutes or two people 6 minutes on the treadle pump. From 20 - 15 psi the pressure tank discharges enough water to meet the weekly demand of 1/6 of the crop. The drip irrigation system is plumbed into six sections for this purpose.

3.3 Best Farming Practices

Best farming practices will be implemented to minimize water use. The water demand for the areas requiring irrigation are 25.4mm/wk (one inch per week). Using a straw mulch factor of .6 and a drip irrigation factor of .73, only 43.8 percent of water is required when irrigating from the storage tanks. The greenhouse does not use drip irrigation, and therefore requires 60 percent of the demand due to straw mulching. The plants and drip emitters are spaced at .45m along rows. There are two rows per 1.35 metres, leaving .45 metres between rows and .9m between rows for gardeners to walk. The root area of each plant is watered, and is $.009m^2$, sized for turnips, totalling in $3.3m^3$ per week before mulch factor and drip factor. Each plant in the field has its own drip emitter.

4 Discussion

In order to correctly size the catchment area and storage tanks for optimized real-world performance, a mathematical model of the system was run using 55 years of precipitation data (November 1950-December 2005) from a weather station at the Guelph Arboretum, adjacent to the farm property. This model took into account many factors, including but not limited to rainfall event initial loss to the first flush system, snowfall accumulation and spring melt, augmentation of crop demand by direct rainfall and overall capture efficiency factors. Periods when the tank storage went to 0 (crop demand not being met) for longer than 7 days were deemed “failure events“ and the number of years with at least one failure event were summed and divided by the 55-year model period in order to give a value for annual likelyhood of failure. Catchment area and tank size were optimized using the model iteratively to achieve 10 percent chance of failure (one year of failure in 10 years of operation). A cost sensitivity analysis using the catchment-tank relationship to a specific chance of failure revealed that only 5 percent savings on the catchment and tank price was yielded by downgrading to twice the chance of failure (20 percent). The cost of catchment surface and tanks was the only variable cost in the system analysis: $9485 optimized at $264m^2$ surface and $19.1m^3$ storage. Other costs are drip irrigation at $10,300, $65 for piping, $1,150 for the pumping system, and $5,000 for additional construction materials. The total system cost is $26,000.

Acknowledgement

Thanks to Ann Clark from the GCUOF who provided valuable information throughout the design process.