Hydroponic Agriculture: Commercial vs. Individual Growth in New Mexico

New Mexico

Supercomputing Challenge

Final Report

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LAHS72

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Summary:

New Mexico has a historical problem with water conservation and food production, either wasting the water available or importing billions of dollars of food. The purpose of this project was to find new sources of farming by compare the benefits of using both conventional systems and hydroponic systems. We would create a code that would predict how much water would be conserved, how much food would be produced, and lists all the variables you need to grow with each farming system. The project started off with physical models that would calibrate the code from data collected by our team and other companies. This includes finding all the variables and errors made during the observation process. Next the project made the predictions of water conserved and food produced applied to how much Santa Fe County could save from using hydroponic systems. Next the project analyzed the code itself and why it did not work. The project acknowledged the problems experienced and how our team will fix it as we continue to work on the project. Lastly, the project went over what our team can still improve, if hydroponic systems work more effectively, and if we can advance the use of hydroponics in the future.

For decades New Mexico has struggled with maintaining the right balance between conserving water, producing adequate amount of vegetables and other products, and increasing the growth of businesses and farms throughout the state. Since the Spanish colonial times, acequias were the main form of agriculture in New Mexico, and as of 2005, 3 million acre feet/year of water was consumed to produce agriculture- 78% of the total water supply throughout the state. Because of this, businesses and jobs are not able to be created due to the lack of water to support an influx of workers and production sites. An average of $4 billion dollars of food is imported into New Mexico annually. And by 2050 the earth will be home to as many as 10 billion people, a population that the present food system cannot reach. These are all the daunting prospects that scientists and graphs have observed, and they all urge New Mexico to adequately prepare and provide for its citizens in the future. In this project, we looked in to what he benefits of both hydroponic and conventional farming systems are, what components each system will need to grow effectively, and if using hydroponic systems conserves water and produces adequate amounts of food. Then we used the observations made and the data from as many companies as possible to create a code or modify another skeleton code to predict the amount of water conserved and food produced in both farming systems.

We started off researching all of the components needed to grow produce in both farming systems. The hydroponic system is a method of growing plants in a water based, nutrient rich solution. Hydroponics does not use soil, but instead the root system is supported using an inert medium like perlite to hold the plants in its open bottom container. Water does not have to be replenished constantly, but is pumped throughout the system, distributing the nutrients to the roots spread throughout. The water supply must be shielded from the sun so that algae does not grow and cause problems to the system or the plants. For both the hydroponic system and conventional farming system, we used a 4x2x1 cubic feet container to hold the soil and/or plants in them. we then started to grow lettuce in each container, watering the soil in the conventional farming system and calculating the parts per million of nutrients still circulating throughout the hydroponic system. The first round of seed used in the hydroponic system died because of human error caused by letting the roots grow and then putting them into their mesh pots instead of letting the seeds grow in the mesh pots at the start. In the end, after all of the observations and tweaks to the systems, we came up with the data collected from just two tests:

Hydroponic System:	
Amount:	**1.3 kg**
Time:	**1.5 months**
Amount of Water in 1.5 months:	**512 oz**
Nitrogen Solute:	**4%**
Phosphate Solute:	**2%**
Potash Solute:	**12%**
Volume:	**8 ft^3**
Cost:	**$103.49**
KJ/day:	**3,402**

Conventional System:	
Amount:	**1.3 kg**
Time:	**2 months**
Amount of Water in 2 months:	**960 oz**
Volume:	**8 ft^3**

Cost per 2 months:	**$26.99**
KJ/day:	**2,016**

The amount of food produced and the time it took to grow lettuce was accurate with the averaged amount of time it took to grow this amount of lettuce, according to several studies from the Arizona State University and other reports. In addition to this, we looked into the extra costs of the materials used in each system:

Cost Comparison($):			
Conventional Materials:		**Hydroponic Materials:**	
16.00	**Soil**	**16.50**	**Water Pump**
10.99	**Containers**	**9.05**	**Floral Growth**
		11.99	**TSB Meter**
		7.95	**Starter Cubes**
		9.94	**Net Pots**
		21.03	**Spray Paint, BRS Adapter, 3 Washers, 2 O-rings, 2 Bushings**
		16.04	**Small Braided Tube, Big Braided Tube**
		10.99	**containers**
Total: $26.99		**Total: $103.49**	

Based off of this data we can see that the cost of using hydroponics systems outweighs that of conventional farming systems. However, we were right in our assumption that the hydroponic system proved to be more efficient in conserving water than the conventional farming system. After harvesting, the amount of water used by the conventional farming method totaled 960 ounces, while the hydroponics system only used 512 ounces of water. The hypothesis was also proven correct in the electricity aspect of the experiment. The conventional farming method only required electricity in the lights, and therefore the hydroponics system utilized close to 1,400 more kilojoules of electricity per day than the conventional farming method. If the experiment was continued for two years, the total amount of water used for the conventional farming method would add up to 11.5 thousand ounces. That means if the experiment was continued for two years, the hydroponics system would save over 5,000 ounces of water.

With this information, we wanted to see whether this amount of production would be enough to supply a county in New Mexico. We decided to use Santa Fe county to make predictions as to how much water could be saved trying to feed the inhabitants of Santa Fe county per year. Santa Fe County currently estimated a population of 148,750 people, and there are more than 715 farms in Santa Fe county, with an average size of 434 acres, either using conventional farming methods, hydroponic methods, or other. There were four aspects that we focused on: Hydroponic systems scaled to commercial sized farms, conventional systems scaled to commercial sized farms, hydroponic systems scaled to an individual’s use, and conventional systems scaled to an individual’s use. To get an idea of what individual 8 cubic feet containers could produce, the hydroponic system produced 1.3 kilograms in the span of 1 1/2 months. Assuming that every batch took an equal amount of time and the same amount of water (512 oz), then 10,515,502 kilograms of Lettuce could be produced in 1,011,105.926 years. The amount of water used would be 1,294,215,631 oz in that same amount of time. The conventional system produced 1.3 kilograms over the span of 2 months. Assuming that every batch took an equal amount of time, but 96 oz of water once every week, then 10,515,502 kilograms of lettuce would be produced in around 1,348,141.282 years. The amount of water used would be 4,141,489,873 oz in that same amount of time. To get an idea of what an average 434 acre-sized farm could produce, 1.3 kilograms per 8 cubic feet in 1 1/2 months produced in the hydroponic system would equal around 3,072,069 kilograms from 434 acres in 1 1/2 months. This would equal around 24,576,552 kilograms in one year. The amount of water used would be around 164,191,054 oz in that time period. 1.3 kilograms per 8 cubic feet in 2 months produced in the conventional system would equal around 3,072,069 kilograms from 434 acres in 2 months. This would equal around 18,432,414 kilograms in one year. The amount of water used would be around 278,953,920 oz in that time period. These big amounts have implications that hydroponic systems would be able to produce huge benefits for a depleted state like New Mexico, let alone Santa Fe county. The next portion of the project is to create a database that companies and individuals could use to grow their own produce and further expand the use of hydroponic systems.

The method we tried to use as a program was growing an individual farm to test how to works and the challenges in starting a small hydroponic farm. With the new information we gathered we wanted to make it easier for people to start their own hydroponic farms by using a user friendly code to help them. The code would tell the users what they would need to grow the desired crop and how much water they would use in each system. The code portion of the project was the most challenging part, as there was not enough data to make the code accurate enough, and there were so many components needed to be infused into a code that it was hard to find a start or a continuation of a code that we could test, which would have to convert a physical model to a computer model. The basic structure that was first created was a general arraylist which lists the starting vegetables we want to include in the program. It then asks the user what they want to search. The program will then search through the arraylist and print out information about the desired vegetable components needed to grow.

```
package vegetables;
```

```
import java.util.ArrayList;
import java.util.Arrays;
import java.util.Scanner;
import java.util.Collections;

public class Main {

 public static void main(String[] args) {
		// TODO Auto-generated method stub

		ArrayList<String> vegetable = new ArrayList<String>();
		Scanner scan = new Scanner(System.in);
		String name;
		int amt;
		boolean truee = true;

vegetable.add("Lettuce");
		vegetable.add("Potatoes");
		vegetable.add("Corn");
		vegetable.add("Tomatoes");

		while (truee == true){
		int Min = -1, Max = vegetable.size(), out = 0;

		int Mid = Min + (Max - Min) / 2;

		Collections.sort(vegetable);

		System.out.println(vegetable);

		System.out.println("\n" + "What is the vegetable you are looking up?");
		name = scan.next();

boolean found = false;

		while (found == false) {
			String mid = vegetable.get(Mid);
			int compare = name.compareToIgnoreCase(mid);
			if (out == 20) {
				System.out.println("Vegetable Not Found");
				found = true;
			}

if (compare == 0) {
				System.out.println(name + " is found");
				out = 1;
```

```
                found = true;
            } else if (compare < 0) {
                Max = Mid;
                Mid = (Min + Max) / 2;
            } else if (compare > 0) {
                Min = Mid;
                Mid = (Min + Max) / 2;
            }
            out ++;

        }

if (name.equalsIgnoreCase("potatoes")){
            System.out.println("How many seeds are you going to plant?");
            amt = scan.nextInt();
            System.out.println("To grow " + amt + " potatoes you need " +(amt* 10)
+ " square inches of stonewool. \nNutrients required will need to be resupplied after initial
input of nutrients. \nThe best hydroponic system to use is a water culture system with the
rockwool \non top of the water and a airstone and air pump, pumping air up through the
container. ");
        }
else if (name.equalsIgnoreCase("lettuce")){
            System.out.println("How many seeds are you going to plant?");
            amt = scan.nextInt();
            System.out.println("In order to grow "+ amt+ " seeds, you need to space
them 1 inch apart so about"+(amt*1)+" square inches of space on a panel like polystyrene
panels and grow the lettuce in net pots. \nNutrients required will need to be resupplied after
initial input of nutrients. \nThe best hydroponic system is a N.F.T. system, a Ebb and Flow
technique, or a water culture technique.");
        }

else if (name.equalsIgnoreCase("Corn")){
            System.out.println("How many seeds are you going to plant?");
            amt = scan.nextInt();
            System.out.println("In order to grow " +amt +" seeds, you need to plant
them 1 inch deep in Rock wool or perlite vermiculite. \nNutrients required will need to be
resupplied after initial imput of nutrients and need to be high in nitrogen. \nThe best systems
to use is a Ebb technique, which means put the rock wool on top of the water and after
germination let roots dangle in the water. \nCorn also needs to be pollenated. It occurs
naturally by wind or you can do it by hand. ");
        }
else if (name.equalsIgnoreCase("tomatoes")){
            System.out.println("How many seeds are you going to plant?");
            amt = scan.nextInt();
            System.out.println("In order to grow " +amt +" seeds, you need to plant
in net pots that are supported by the panels similar to lettuce. \nNutrients required will need to
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be resupplied after initial input of nutrients. \nThe best hydroponic system is either  N.F.T.
system, a Ebb and Flow technique or a water culture technique.");
                    }

else if (name.equalsIgnoreCase("tomatoes")){
                              System.out.println("How many seeds are you going to plant?");
                              amt = scan.nextInt();
                              System.out.println("In order to grow " +amt +" seeds, you need to plant
in net pots that are supported by the panels similar to lettuce. \nNutrients required will need to
be resupplied after initial input of nutrients. \nThe best hydroponic system is either  N.F.T.
system, a Ebb and Flow technique or a water culture technique.");
                    }
System.out.println("Is their another vegetable you want to look up? (Yes or No)");
                    String answer = scan.next();
                    if (answer.equalsIgnoreCase("yes")){
                              truee = true;
                    }
                    else {
                              truee = false;
                    }
                    }
                    System.out.println("Goodbye");
          }
}
```

However this code did not work properly, finding errors in the syntax that could not be fixed without changing the structure of the whole code, rendering what we had made essentially useless. After several attempts of changing the structure, the list of variables made it hard to create a program that would easily display our results and predictions. One way of creating or at least modify an already existing code is to borrow code from Cotton 2K open source code to get predictions based on what the user wanted to grow. The program only runs on PC or Windows computers instead of macintosh, which we have used for the majority of this project.

In the end, the code that we had worked on all year had not worked. While hydroponic systems are growing in popularity around the globe as an alternative to conventional forms of farming, there are still problems with the current misuse and waste of water throughout New

Mexico and other parts of the globe. And while it did not work, it would still be interesting to see how companies could further expand the use of hydroponic systems and how consumers would use data presented to them for both forms of farming in a program or database. When we teamed up together to start this project, we had no real experience with programming, just a few computer science classes that taught very little coding. After this project, we have created a better understanding of the programming language and how we can use it in the future, along with the prospect that we have a better understanding of the water issues and forms of alternative aid in New Mexico. We were able to conduct the research and brainstorm and start with a basic understanding of the code we wanted with the help of Adam Drew, an employee of the Los Alamos National Laboratory who agreed to help mentor us whenever he had the time. The other mentor we would like to acknowledge is Donald Davis, an employee of the Los Alamos High School who started us on the project of going into hydroponic systems and helped create a list of components and procedures that we could follow. We would also like to thank the New Mexico Department of Agriculture for helping us find references and companies. While the actual code was a bust, there was plenty to learn and still plenty to do, with the project, with the current water issues, and with New Mexico as a whole. We will continue to work until a code is finished and companies are able to use it for customers as a reference to further the use of hydroponic systems.

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