Agronomics Preliminary Engineering Technical Memorandum

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Introduction

Food production is unquestionably the most important aspect of the greenhouse. After all, it is the end result that everyone cares about; fresh, healthy food. To serve the Dine people of Tolani Lake, there is a variety of food to choose from. These vegetables and herbs all have their own specific growing needs, and they all need to be met simultaneously for each plant to have a chance at producing usable, consistent food.

2.1.1 Crop Selection

Crop	Yield	Harvest	Seed Cost
Strawberries	Approximately 2.5 pounds per plant	4-6 weeks after blooming	Approx. $4.99 for 500 seeds
Carrots	one stock per plant	70 days stow to harvest	Approx. $5.00 for 500 seeds
Onions	one stock per plant	100-120 days after planting	Approx. $1.99 for 400 seeds
Tomatoes	12-20 pounds per 10 ft row	60-85 days after planting	Approx. $2.75 for 20 seeds
Jalapeños	25-35 pods per plant	70-80 days after planting	Approx. $2.49 for 30 seeds
Serranos	40-50 pods per plant	80 days after planting	Approx. $3.25 for 200 seeds
Habaneros	30-40 pods per plants	95 days after planting	Approx. $3.30 for 100 seeds
Swiss Chard	8-12 pounds per 10 ft row	55-60 days after planting	Approx. $3.50 for 500 seeds
Kale	5-10 pound per 4 ft row	55 -60 days after planting	Approx. $6.99 for 500 seeds
Cabbage	1-3 pounds per plants	90-120 days after planting	Approx. $6.99 for 500 seeds
Celery	6-8 stalks per plant	175 days after planting	Approx. $2.82 for 500 seeds
Cauliflower	6 heads per 10 ft row	55-100 days after planting	Approx. $5.99 for 100 seeds

Broccoli	4-6 pounds per 10 ft row	308 days after planting	Approx. $5.99 for 200 seeds
Bush Bean	3-5 pounds in 10 ft row	50-60 days to mature	Approx. $7.79 for 100 seeds
Lettuce	5-10 pounds per 10 ft row	70-80 days after planting	Approx. $1.79 for 1000 seeds
Cilantro	not limited once the is grow harvest the top and it will continue to grow	70 days after planting or 100 days for seeds	Approx. $3.74 for 175 seeds
Parsley	not limited once the is grow harvest the top and it will continue to grow	28-48 days for it to spout. 14 days for new leave to mature	Approx. $3.25 for 600 seeds
Basil	4-6 cup of leaves per week	48 days before first harvest.	Approx. $1.61 for 100 seeds

If the EPICS team were to buy the seed at the prices listed above the we would spend a total of $74.23 and have a total of 6025 assorted seeds. This should be more than enough to create the 800 sproutlings needed for the tower gardens.

2.1.2. Nutritional, Pollination, & Pest Control Requirements for Crops

Plants must obtain 14 nutrients in order to grow. The primary macronutrients, that make the up the majority of the necessary nutrients are nitrogen, phosphorous, and potassium. The secondary macronutrients are calcium, sulfur, and magnesium. The micronutrients that are required in only small quantities are boron, chlorine, manganese, iron, zinc, copper, molybdenum, and nickel. In conventional farming, plants absorb these nutrients from the soil (25). In an aeroponics system, a nutrient solution is diluted with water and is continuous fed to the plants. Tower garden manufactures a nutrient solution specifically designed for the aeroponics system that the EPICS team will employ for testing. To reduce operational costs, there will be efforts to produce the nutrient solution from the raw materials.

In an aeroponics system, maintaining the appropriate pH level in the water for the plants is crucial for the success of the plants. On average, the optimal pH for plant growth is between 5.8 and 6.3. Leafy green vegetables like lettuce and spinach, cruciferous vegetables like broccoli, cauliflower, cabbage, and kale, and other cold-season vegetables prefer a more alkaline soil with a higher pH. Fruiting plants like tomatoes and peppers prefer a more acidic soil, with a lower pH (26). Oxygen content is also incredibly important for a plant's success. Aeroponics allows the water to be highly oxygenated, cause the plants to grow more quickly and the plant density to be higher.

The Solanaceae family that includes tomatoes and pepper are self-pollinating, and while the plants are able to bear fruit without external pollination, wind can expedite the pollination process (22). All leafy greens, herbs, root vegetables, and most legumes do not require any pollinators to produce (23). Members of the Cucurbitaceae family, that include cucumbers, melons, and squash requires cross-pollination and do not thrive in greenhouses. Moreover, individual families grow melons and squash in home gardens using dry-farming techniques. Thus, the EPICS team will not include plants of the Cucurbitaceae family in the pilot greenhouse.

In a greenhouse, pepper plants can be prone to aphids, spider mites, and fungus. Neem oil has been shown to prevent such pests. Neem oil is readily available at gardening and outdoor stores. A diluted neem oil solution should be sprayed on the pepper plants every 2-3 days. Neem oil is non-toxic to most plants and animals; it causes no harm when entering the body, but it can cause slight irritation to the skin and eyes (24).

2.1.3 Seasonal-Circadian Variations in Requirements

Plants are typically divided into two different seasonal categories: warm and cold (28). Warm seasonal plants, such as tomatoes, squash and peppers, are suited to more temperate climates, and are sensitive to temperatures below 45-50 degrees Fahrenheit. Cold season plants benefit from growing in an environment that is below 70 degrees Fahrenheit, and can handle occasional dips in temperature (29). Growing both types of vegetables simultaneously in one greenhouse would require either two compartments that are insulated from each other, or one temperature that is maintained year round that suits both types of plants. To keep costs down, it is recommended that the two types of vegetables are grown one at a time, with the Warm seasonal plants grown in the summer and warmer months, and the Cold seasonal plants grown in the colder months. This will lessen the energy requirements of the greenhouse as ambient temperature will play a large effect in heating and cooling costs. If the optimum growing temperature is similar to the ambient temperature outside, less energy will be needed to maintain that environment, in turn allowing for a more simplistic design.

Crop growth will be slowed in the winter, as light levels within the greenhouse will decrease (30). To ensure consistent growing year round, supplemental lighting is possible. Some plants, however, such as tomatoes and peppers, will actually die if they are in constant light without darkness, however most other plants will relish in the continued light given to them for photosynthesis. If lights are going to be used at night to supplement plant growth, it is recommended that tomatoes and peppers are covered from the lights for at least 8 hours every day (31).

2.1.4 Recommended Methods for Growing Crops

The are two different pressure systems that are feasible for this project, high and low pressure (27). Low pressure systems are simplistic, typically consisting of a small water pump

pumping water that is then aerated as pumped water and nutrients are splashed onto roots. These systems typically only need the pump, and watering is actually done with gravity. Plants are typically better arranged with verticality in mind, allowing for gravity feeding of nutrients and water. These arrangements can be either completely vertical columns, such as the commercially available Tower Garden, or constructed in an A-frame, either system allows for a greater crop density per square unit length, increasing the overall yield. With High pressure systems (60-90 psi), more oxygen can make it to the root systems, which will increase crop yield, however the system is much more complicated. The system relies on built up pressure to release a mist of water onto the root system, which is more efficient than the splash system utilized by low pressure systems. Doing this requires a fully pressurized system, including components such as a small air compressor, an accumulator tank, and a cycle timer, which would be needed to appropriately water each crop. This would create problems with large scale implementation, and as such it is recommended that the REAP Greenhouse utilize a simplistic, low pressure system for their crops to ensure consistent growing of crops.

By utilizing a low pressure system, REAP will only need to acquire a few components in bulk to construct a large system capable of producing food on the scale that the people of Tolani Lake need. These components would include:

- Fountain/Pond Pumps - Water requirements of each plant will vary, and as such pumps with varying Gallons per Hour will need to be acquired. Expected range of pump prices is 18.00-30.00.
- PVC piping - Diameter will vary with regards to water requirements, but prices range between 3.00 and 8.00 dollars for 10 feet of piping.
- Seedling bedding - material such as furniture stuffing will do, it simply needs to hold the plant in place. This could be easily donated, or acquired for little to no money.
- Structural wood - A cheap, sturdy building material, Wood would be used to construct the frames of the aeroponics system if systems are to be built by team. $2.75 for an eight foot 2x4.
- Reservoir - To hold water and nutrient mixture. $70.00-100.00.

A fully ready commercial product that utilizes a gravity fed, low pressure system, is the Tower Garden (32). The Tower Garden is capable of growing 20 plants simultaneously, and are commercially available for roughly 500. When bought in excess (more than nine according to a sales rep), the Tower Gardens are acquired through the company of the inventor himself, who becomes a consultant in the project. Given the prices for materials, it is much cheaper to construct the systems for the Greenhouse on site. It is recommended that the team comes up with their own design that utilizes a gravity fed system. This would allow for greater usage of vertical space, increasing the density of crops in the greenhouse. An A-frame design would be one of the

easier structures to create, and there are many examples of this structure already proving its usefulness (33). No permits are required to construct these systems.

Conclusions:

Next semester the EPICS team will have to conduct research to determine the configuration of the plants that will maximize yield, while minimizing time and effort. This selection of food will not only provide the largest amount of people with the nutrients that they need to survive, but also satisfy the demand for crops of their choice. A simple structure will be designed based on other successful low-pressure aeroponic designs. The team will then find the most optimal grouping for the selected crops. With time, these technical choices will undergo further development as the project turns into a reality.

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