ENVR 300

Proposal Final Version

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Working Title:

A Comparative Analysis between Hydroponic and Traditional Greenhouse Methods of Red Tomato Production Using Different Light Sources in Nezahualcóyotl, Mexico.

Summary:

This proposal aims to determine the feasibility of cultivating red tomatoes (*Solanum lycopersicum*) via traditional greenhouse methods and three types of hydroponic methods using natural sunlight and LED lighting in Nezahualcóyotl, Mexico. This feasibility will be investigated based on financial costs, environmental strains, and energy parameters. This investigation is relevant at this point in time as the land of Nezahualcóyotl is infertile, external food sources are unreliable, and water is a limited resource. Thus, food security is an increasingly heightened issue faced by the residents. This investigation will then allow the government to determine if these urbanized forms of agriculture could persist in Nezahualcóyotl.

Introduction:

With projections of a world population being 70% urbanized by 2050, there are growing concerns for the food security of cities (Al-Chlabi, 2015). Nezahualcóyotl in Mexico is a city that alongside poverty faces these food security issues due to land unsuitable for traditional agriculture and due to the scarcity of water (Anda & Shear, 2017). Hydroponics, the crop cultivation method that utilizes nutrient solutions instead of soil could have potential in this region (Lee & Lee, 2015). Similarly, traditional greenhouse methods could be plausible based on the availability of land to implement greenhouses (USAID, 2017). Yet, little research has been conducted to determine the environmental strains or the cost-effectiveness of these agricultural methods in a city like Nezahualcóyotl where field-based farming is not viable. Furthermore, with red tomatoes (*Solanum lycopersicum*) being such a staple component of Mexican cuisine, there hasn't been much research involving production of these tomatoes in Mexico via urban agricultural methods either (Lares-Michel et al., 2018).

Based on this gap of literature, this research project aims to conduct an experiment using three types of hydroponic methods and a traditional method to cultivate red tomatoes (*Solanum lycopersicum*) using different light sources to determine the feasibility of such methods in Nezahualcóyotl. Subsequently there will be an analysis of the financial costs, the environmental strain via energy and water usage, and the quality of the crops via various quality parameters. Thus, the following research questions need to be addressed:

- What are the differences in quality (based on yield, tomato size, ascorbic acid content, beta-carotene content) of the tomatoes produced between traditional greenhouse methods and hydroponic methods with natural light and LED lighting?
- What are the differences in energy consumption and cost in tomato production between traditional greenhouse methods and hydroponic methods with natural light and LED lighting?
- What are the differences in water consumption and cost in tomato production between traditional greenhouse methods and hydroponic methods with natural light and LED lighting?
- Based on the previous questions which production method is most cost-effective and environmentally sustainable for a city like Nezahualcóyotl, while maintaining quality?

Currently in Mexico over half the land is insufficient for agricultural farming and there appears to be an increasing scarcity of water. From 2007 up until 2017, Mexico's rural crop productivity has been less than 1.1% (Anda & Shear, 2017). This is concerning since the majority of its population suffers from nutritional health problems (Rivas & Galicia, 2017). Nezahualcóyotl is a city of particular interest due to its history of slum-like conditions where there has been difficulty in providing basic services to its low-income population (Aguilar, 2002). Moreover, this region isn't very well-suited to agriculture due to its presence on what was the Lake Texcoco (Mazur, 1994). Salt deposits left behind from the lake have rendered the land infertile (Yee, 2017). This means that there is no local source of fruits and vegetables and those that are bought from rural regions in Mexico are not entirely safe due to the prevalence of untreated sewage in irrigation and that which is rising into the air (Mazur, 1994). The cultivation of red tomatoes in particular is problematic within field-based agriculture due to frequent pesticide usage (Lares-Michel et al., 2018). Thus, investigating the feasibility of hydroponics and traditional greenhouse production of tomatoes, which are both culturally significant and nutritious, is relevant at this point in time because Nezahualcóyotl is not at all food secure.

Methods:

This experiment will be advised to occur on a plot of land adjacent to the Cinema in Nezahualcóyotl. It will be proposed that 2 separate 8 X 12 greenhouses be constructed on this land to facilitate the experiment. There will be effectively four different treatments in which each treatment will consist of 50 seeds in individual pots which are in 5 replications of 10 seeds each. The treatments are traditional greenhouse tomato production methods and three types of hydroponic tomato production methods.

The hydroponic methods are the wick system, the drip system, and the aeroponic system. The wick system utilizes a wick to deliver both the nutrient solution and water. The drip system utilizes a pipe system in which an electrical motor delivers nutrients and water through a pipe to the plant once a day (Kaur et al., 2018). These two methods will require a medium of peat and vermiculite (Kaur et al., 2018). The aeroponic system on the other hand does not

require any medium (Lee & Lee, 2015). The water and nutrient solution are delivered via a misting system where they are misted towards the roots based on an electrical timer once a day. The greenhouse method will use organic production methods where the medium utilized is soil combined with peat and vermiculite (Carballo-Mendez et al., 2018). Additionally, for the greenhouse methods water and nutrients will be delivered once on a daily basis while compost will be supplemented prior to the growing season (Carballo-Mendez et al., 2018).

Within these treatments there are 2 different scenarios one in which only natural sunlight is utilized to supply energy to the plants and the other in which LED light is constantly provided as energy to retain consistency. These scenarios will occur in separate greenhouses. The hydroponic system will not require pesticides as it is noted to be resilient in the face of pests and disease (Anda & Shear, 2017). In terms of pest production in the greenhouse methods, there also will be no synthetic pesticides or herbicides utilized. Pests will be treated only if necessary, with microbials such as Safer Soap which includes potassium salts of fatty acids (Letourneau & Goldstein, 2001). Overall, the crops will be examined twice on a daily basis to ensure that there are no active production risks such as pests or disease.

The winter crop will be sown in July and is expected to be harvested in December. While the summer crop will be sown in October and is expected to be harvested in April (Kaur et al., 2018). Once the tomatoes are harvested, they will be analyzed for each method based on yield, weight, ascorbic acid content, beta carotene content. Yield will be determined based on the amount of tomatoes produced per plant, weight will be determined by the average weight of the tomatoes per plant, and ascorbic acid and beta carotene content will be determined using spectrophotometry (Gautier et al., 2008; Kaur et al., 2018). These quality parameters will be quantitatively compared to determine which method produced the healthiest tomatoes. Subsequently the energy and water consumption for the tomato production methods in natural and LED light will be computed. This will allow the determination of the financial costs associated with these environmental strains, thereby allowing for a cost-effectiveness analysis.

Budget:

The budget values mentioned below in USD were computed based on a case study of a hydroponics farm in Brazil (Souza et al., 2019).

Item	Cost
Greenhouse Production (192 m^2)	$11,000 USD
Electric System	$6,600 USD
Hydraulic System	$5,000 USD
Misting System	$1,700 USD
Soil (1250m^2)	$600 USD
Nutrient Solution	$2,600 USD
Pesticides (if needed)	$800 USD
Seeds	$900 USD
Compost	$1,600 USD
Peat and Vermiculite	$1,600 USD

Pots	$250 USD
Cotton Wicks (for drip system) – (Kaur et al., 2018)	$20 USD
HPS 600 W lamp lights – (Al-Chlabi, 2015)	$800 USD
Water Consumption – 1L required per square foot daily in hydroponics (Al-Chlabi, 2015)	$8,000 USD
Energy Consumption via Lighting – for hydroponics the crops require 18 hours of lighting a day (Al-Chlabi, 2015)	$6,000 USD
Spectrophotometry (for ascorbic acid/beta-carotene content) – (Kaur et al., 2018)	$200 USD
Field Assistants – 2 for 2 years	$40,000
Total	$87, 670

Timeline:

- A month must be allotted to the construction of the greenhouse and preparation of supplies
- The winter crop will be sown in July in 2020 and 2021, harvest should occur around November/December of 2020 and 2021 (Kaur et al., 2018)
- Following the harvesting process, the quality parameters as well as the consumption parameters will be determined immediately
- The summer crop will be sown in October in 2020 and 2021, harvest should occur around March/April of 2020 and 2021 (Kaur et al., 2018)
- Following the harvesting process, the quality parameters as well as the consumption parameters will be determined immediately

Implications:

This comparative analysis will allow the government of Nezahualcóyotl to understand how traditional greenhouse and hydroponic crop production work. Subsequently, it will help them determine whether either of these methods are viable in Nezahualcóyotl based on the needs of this region. In terms of the general public, this investigation will be impactful as it too will allow them to be more educated in regard to these forms of protected urban agriculture. Furthermore, it will draw more attention to the need for food security within Nezahualcóyotl. In the academic world, this kind of research can allow for further analyses in other parts of Mexico or even around the world either using the same hydroponic methods or different ones. Research could also be done growing different fruits and vegetables to compare the economic and environmental costs.

Total word count: 1620

Revisions:

a) Change the title to include the "when" component

My peer reviewer suggested that I change my proposal title to include the "when" component. I actually ended up not making this change on the basis that I felt my title was already informative. Since I'm not looking back at the past or projecting for the future, I didn't feel the need to include my timeline in the title. I do understand why my peer reviewer made this suggestion as time is really helpful in understanding the purpose of a research paper. However, as I mentioned before my project will occur in present time and so I don't think that needs to be explicitly stated in the title.

b) Explain why red tomatoes are chosen to be the experimenting species

I'm really glad that my peer reviewer brought this suggestion up, as I had completely forgotten about it. Explaining why I choose red tomatoes is very important in my proposal. Thus, I took this advice and I included some reasoning in the introduction to explain the significance of red tomatoes to my project. This was important because I imagine that if I proposed my project as it was, it would have been very confusing, and it would have weakened the proposal.

c) Include complete and explicit costs of all requirements

This was another suggestion that I was really thankful for. I initially felt a bit stressed thinking about the costs associated with my project as I felt the need to make them as accurate as possible. But I realized that after reading my peer reviewer's proposal, it would be okay to make some estimates. Thus, I included complete costs for my budget. This was a necessary adjustment to make as when proposing research, I would need to be fully aware of the costs associated so I can apply for necessary research grants.

d) Add more to the implications in regard to the general public

This was a suggestion that I didn't actually think about. I didn't realize how important it would be to appeal to the general public in my research project. As my peer reviewer mentioned, this is important to do so because it would allow the public to feel connected to the project as it has the potential of changing their lives. Thus, I added a few sentences within the implications to mention the impact in relation to the public.

e) Add to the implications, what your experiment has not done yet

While I understand this suggestion, I felt that the implications already encompassed this. I did mention in the implications already what other research could be conducted; thus I did not make any further changes.

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