
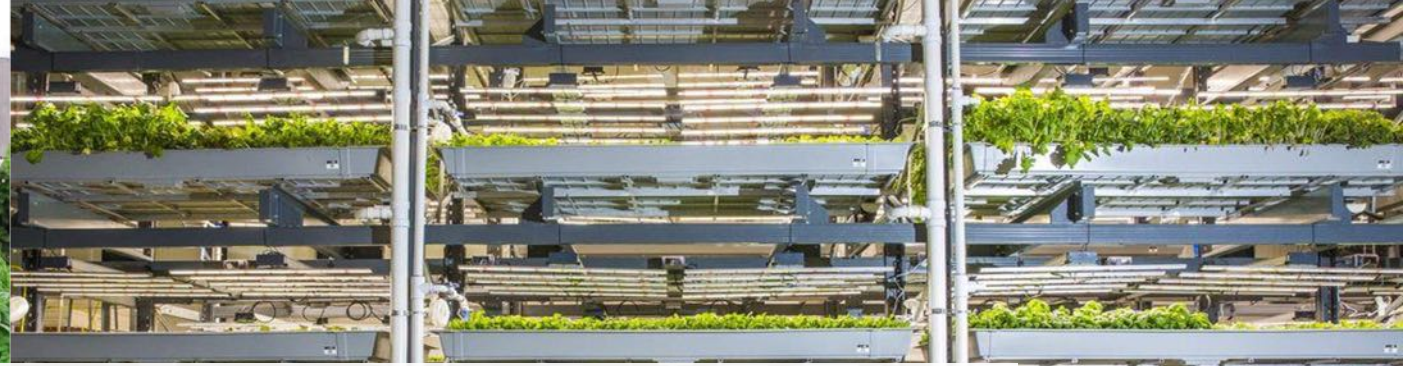



The Impact of City Sounds on Urban Farms

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Abstract

- The research question that was aimed to answer through this study was,
  "**To what degree do city sounds affect the growth of greenery cultivated in the modern method of vertical farming?"**

- Traditional agriculture has been a major source of sustenance for civilians throughout the nation, yet **accessibility of fresh produce at a reasonable price has declined as shipping costs rise**

- A solution to this problem is **urban vertical farms**, which uses vacant spaces in cities to grow crops through **hydroponics**, yet **a possible restraint is sound** as plants have been proven to respond to sounds

- Two identical hydroponic systems were constructed planting lettuce, one was exposed to city sounds played on a speaker at a level of 70 decibels for 6 hours a day, while the other was set in a silent environment

- At the end of the experiment, plants were harvested and ranked on a scale of 0-5 based on health, a chi-squared statistical test was run to show 4 degrees of freedom and a **p-value of 0.7358**, providing evidence that there is no difference between the 2 groups

- **It can reasonably be concluded that urban sounds impose no limitation on the growth and health of vertical farms, and their implementation into cities should continue to flourish**

Research Question

The research question aimed to be answered in this study is, **‘To what degree do city sounds affect the growth of vegetables cultivated in the urban method of vertical farming?’**

Hypothesis

If hydroponically grown lettuce is exposed to urban commotion, there will be a decrease in plant health due to harsh frequency and less carbon dioxide intake.

Rationale

This topic was of interest to me as urbanization is only increasing globally, finding improved ways to nourish communities is vital to the advancement of the agricultural system. Hence, investigating possible constraints of modern farms is important to its future.

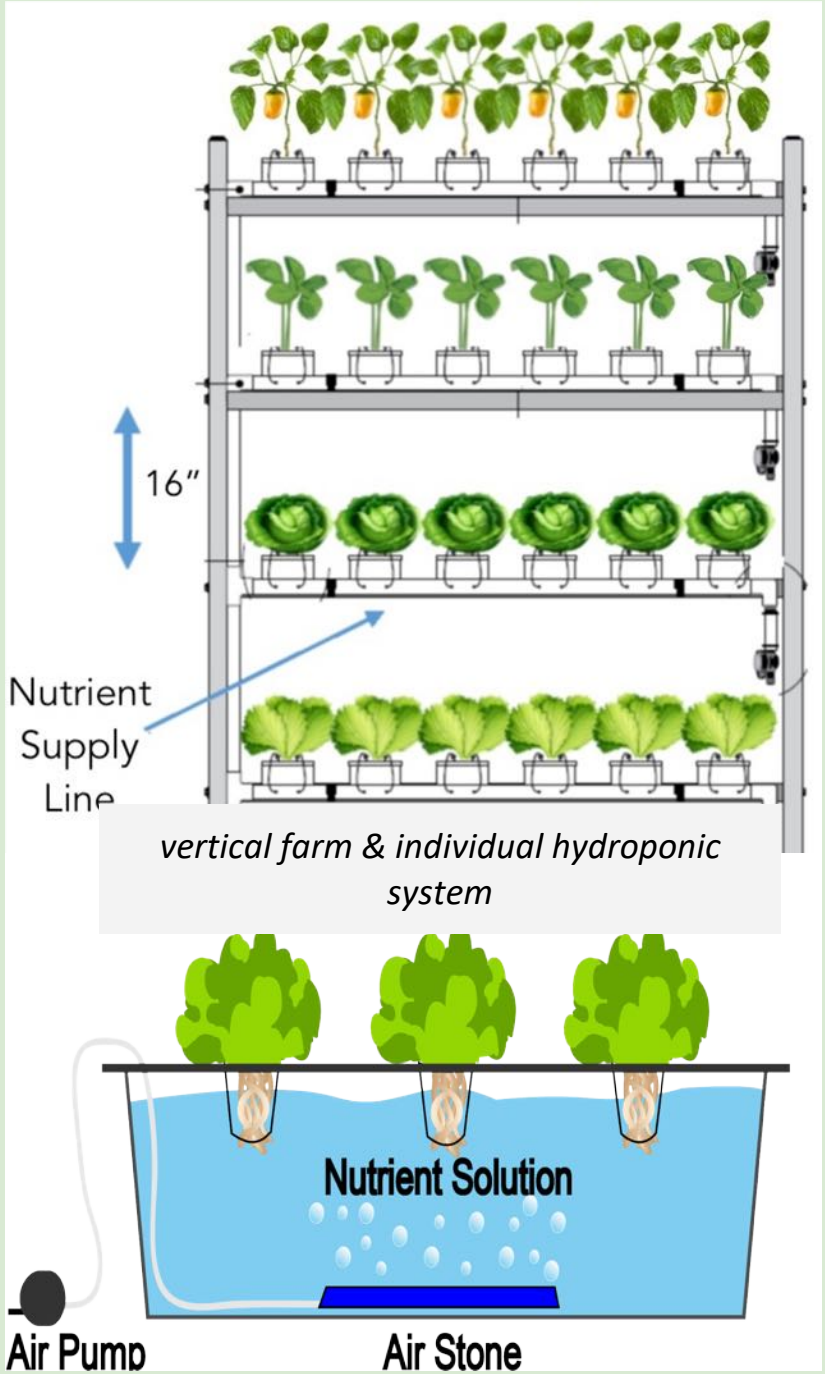
Urban vertical farms hold the potential to eliminate the need for pesticides causing more organic produce, eliminate the costs needed for shipping produce from rural to urban areas, and a greater yield of crops.

Reason of Interest

- This research addresses the following community issue: **urbanization causing shortage of affordable produce for the impoverished**
- I already knew about hydroponics which inspired me to explore its real-world application and the potential of implementing it throughout society

Background Information

- A **vertical farm system** involves crops to be grown vertically in vacant spaces using a **hydroponic** system for watering; they do not require soil as the roots are submerged in a mixed water and nutrient solution composition
- **NASA scientists** have utilized hydroponic systems to grow food in space; they found that **this form of cultivation reduced packaging of supplies** with proper monitoring of nutrient and water levels using software like ChemScan [2]
- A study done revealed **nature sounds** with a main frequency of 2200 Hz **accelerated** a hydroponically grown tomatoes ability to absorb the nutrient solution with elements such as nitrogen [1]
- Tank-farmed lettuce found to **improve growth** at a frequency of 20kHz **using ultrasound waves**, giving an increase in vegetative mass [4]



vertical farm & individual hydroponic system

Methods: Setting Up

- Two identical hydroponic systems were set up using two 56 L plastic tubs to store the water reservoir.
- Lettuce seedlings were germinated 14 days prior to installation in a moist paper towel.
- Once sprouted, they were put into rockwool cubes, the cube was then placed in 2 inch net cups that have holes all throughout to allow roots of the lettuce to reach for the water.
- Before placing the cups into the system, 30 L of water was filled into each of the buckets and 80 mL of CNS Grow nutrient solution was mixed to create the reservoir. The nutrient solution contained a Nitrogen level of 2%, suitable for this experiment. pH was tested for a range of 5.5 to 6.0.
- An air pump was attached to the side of each system along with a 1/4 inch tube submerged into the water with an air stone at the end, oxygenating the water.
- To place the plants in each system, a styrofoam raft with 12 2-inch holes was made. This raft was placed in the water, allowing the plants to float above the reservoir.
- A grow light was hung 8 inches above each system. To ensure an even dispersion of light, a black and white opaque tarp was wrapped around each system.

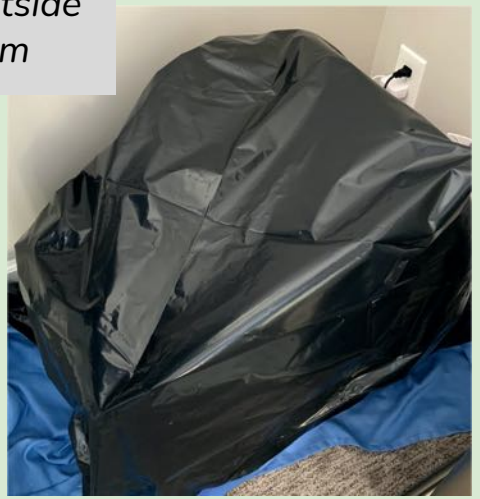
lettuce seedlings in their net cups and rockwool cubes

sprouts in the system

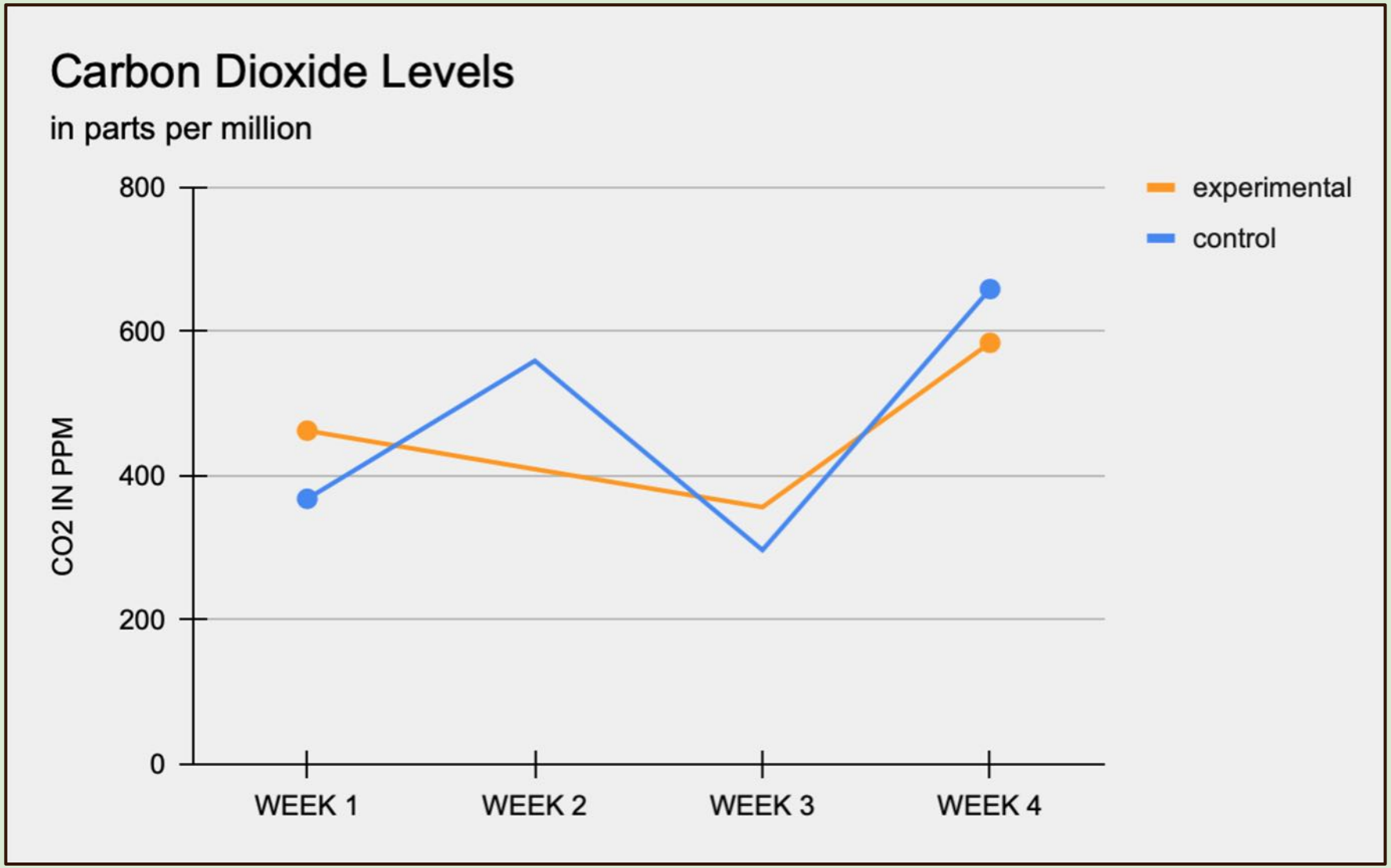
Methods: Conducting Experiment

- Following a week of observation, the plants in each system appeared in equal health, it was time to begin the experiment.
- The control system stayed in a mostly quiet environment while the experimental system was set up in a separate area with the addition of a speaker that played a track of urban commotion at a level of 70 decibels using an MP3 player.
- The experimental system was treated with this sound exposure for 6 hours a day to reenact the typical disturbance one would hear in a city, the time was spread out to 3 hours in the morning and 3 in the evening.
- Every week following the start of the experiment, carbon dioxide levels were measured using a CO2 Gas sensor to determine if sound caused a change in CO2 intake.
- This question was also tested by comparing the stomatal opening (located in the epidermis layer of the plant that regulates oxygen out take and carbon dioxide intake) of each plant in the different environments. A sample was taken from each system by painting a spot of clear varnish on one of the leaves and peeling it off using clear tape once dried. Samples were analyzed on a glass slide with a microscope using 40X magnification.
- After harvested, plant health was evaluated on a scale of 1-5 and crop weight was measured using a scale.

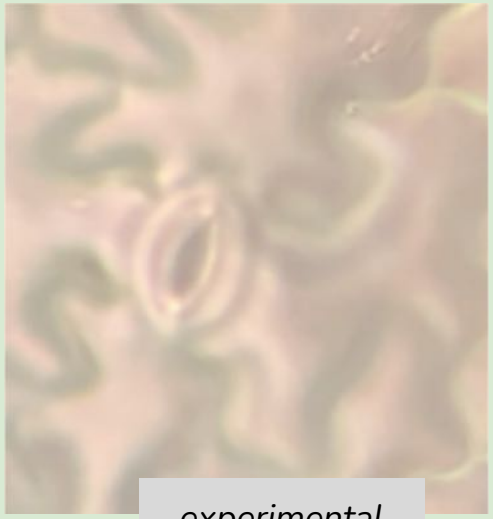
experimental system during sound treatment and outside view of control system



Data Visualizations



control



experimental

p-value of 0.861 (p>0.05)

Discussion

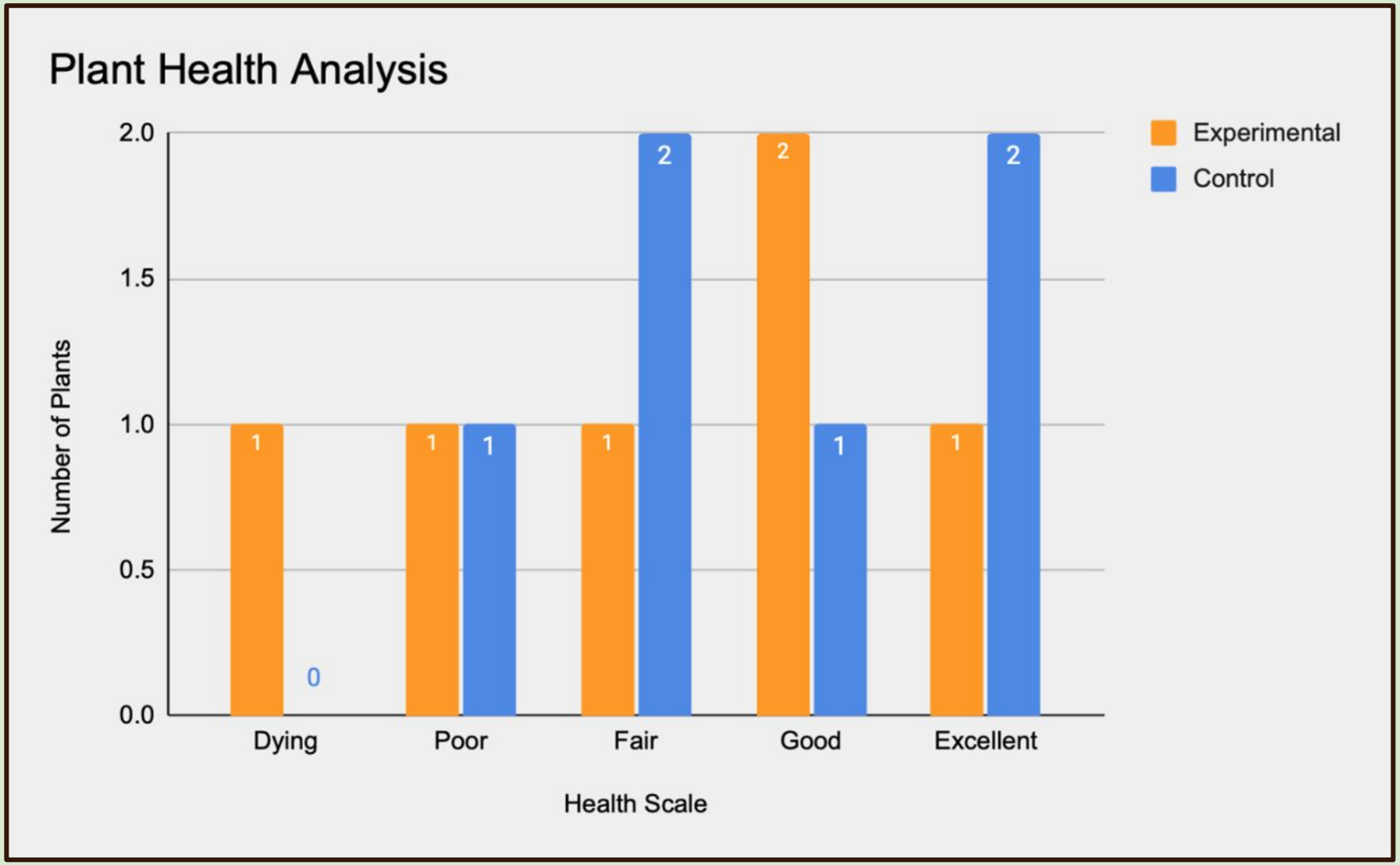
- Based on the results of the t-test, $p>0.05$ hence there was no difference between the two groups meaning the carbon dioxide levels around each system was fairly similar (the addition of sound does not hold an effect).

- During week 3 the CO_2 levels dropped in both systems, this may have been due to the event of low ventilation in each system, supposedly caused by the tarp wrapping around each system. The lack of ventilation also caused a calcium deficiency in the control system, this was fixed by placing a battery-powered fan in each system throughout the day to circulate air flow and oxygen.

- Looking at the two stomatal images of a lettuce leaf from each plant, the experimental appeared to be slightly larger in diameter than the control. This may be due to the finding in a study that the sound's frequency of 3-5 kHz stimulates the opening of the stomata pore[3] which was similar to the frequency the city sounds were played at (2-4 kHz).

calcium deficiency shown in control system, also known as tip turn

Data Visualizations



Final Crop Weight

Control	Experimental
266.49 grams	257.98 grams

p-value of 0.736 (p>0.05)

Discussion

- Based on the results of the chi-squared test, $p>0.05$ hence there was no difference between the two groups meaning urban sounds did not hold an effect on overall plant health.

- This result was affected by the small sample size in this study. Prior to experimentation many of the plants in each system died due to improper lighting and nutrients. This left each system with 6 plants instead of 12.

- The final weight of the control system's crops was 26.49 grams, and the experimental was 257.98 grams. This means that each system produced nearly the same amount of crops, thus city sounds held no effect on crop yield.

Plants in each system before final harvest

Conclusion/Future Steps

- Based on the findings discussed, it can be reasonably concluded that **urban commotion does not impose significant restraints in crops grown through modern methods**, not supporting my hypothesis. Urban sounds do hold the ability to open the stomata however not to an effective degree as there was no greater improvement of CO2 levels.
- **Improvements to my research** can be made such as holding a larger sample size, limiting human error with nutrient solution amounts and water pH, and also **conducting this research in a real-world setting of vertical farms in urban spaces.**
- Knowing this, cities should continue to implement vertical farms to suit the nutritional needs of low-income residents who find fresh reliable produce to be too expensive.
- As for the field of plant sciences, many should continue to investigate the effects of different kinds of sound on other hydroponically grown crops such as spinach, tomatoes, herbs, and other staple fruits and vegetables.
- **I appreciated doing this research for GLOBE and NASA as I was able to not only further my knowledge on new innovations in our society but contribute my findings to bettering our agricultural**

Lettuce when harvested, control on the left and experimental on the right

experimental system during week 4

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