The Impact of City Sounds on Urban Farms

1169

Plant Sciences

Senior Division

Science Type Project

Introduction/Purpose

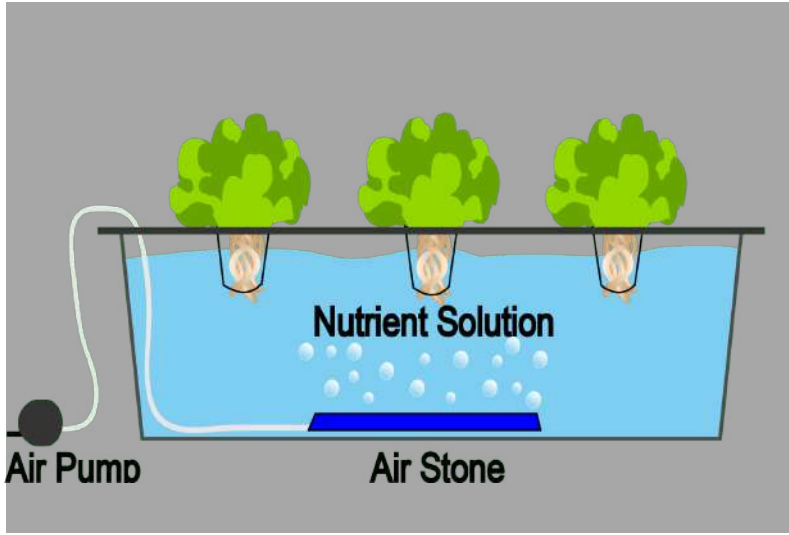
- Long-established methods of agriculture have not become as effective in recent times.

- Many initiatives have been taken in order to reverse these repercussions: vertical farming technology, a system involving food grown in vacant spaces using a hydroponic system for watering.

- **Vertical farms** are a sustainable form of agriculture and are being implemented in heavily populated urban areas such as the city of Cairo which has lowered the cost of produce for poverty-stricken citizens.[1]However **a posed restraint may be city sounds** as plants respond to sound in various ways.

- A study done revealed nature sounds with a main frequency of 2200 Hz **accelerated** a hydroponically grown tomato's ability to absorb the nutrient solution with elements such as nitrogen[2]

- Tank-farmed lettuce found to **improve growth** at a frequency of 20kHz using ultra sound waves, giving an increase in vegetative mass[3]



visual representation of a single hydroponic system

Therefore the question arises, ‘To what degree do city sounds affect the growth of vegetables cultivated in the urban method of vertical farming?’

Hypothesis

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

Variables

Independent
- Addition of sound on experimental system

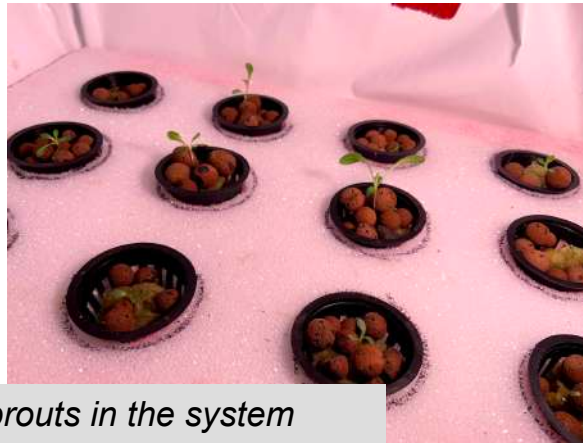
Dependent
- Carbon Dioxide Levels
- Stomatal Diameter (Opening of pore in plants)
- Crop Weight
- Plant Health

Controls
- Amount of Nutrient Solution
- Water Temperature
- Age of Plants
- Amount of Light

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 rock wool 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.

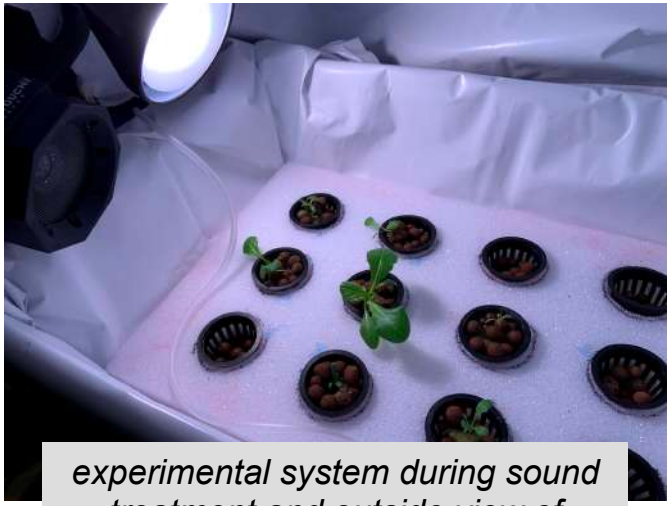
lettuce seedlings in their net cups and rock wool cubes



sprouts in the system

Methods: Starting the 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 CO_2 Gas sensor to determine if sound caused a change in CO_2 intake.
- This question was also tested by comparing the stomatal opening (located in the epidermis layer of the plant that regulates oxygen outtake 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

Testing & Analysis

Do city sounds affect a plant's CO_2 intake?

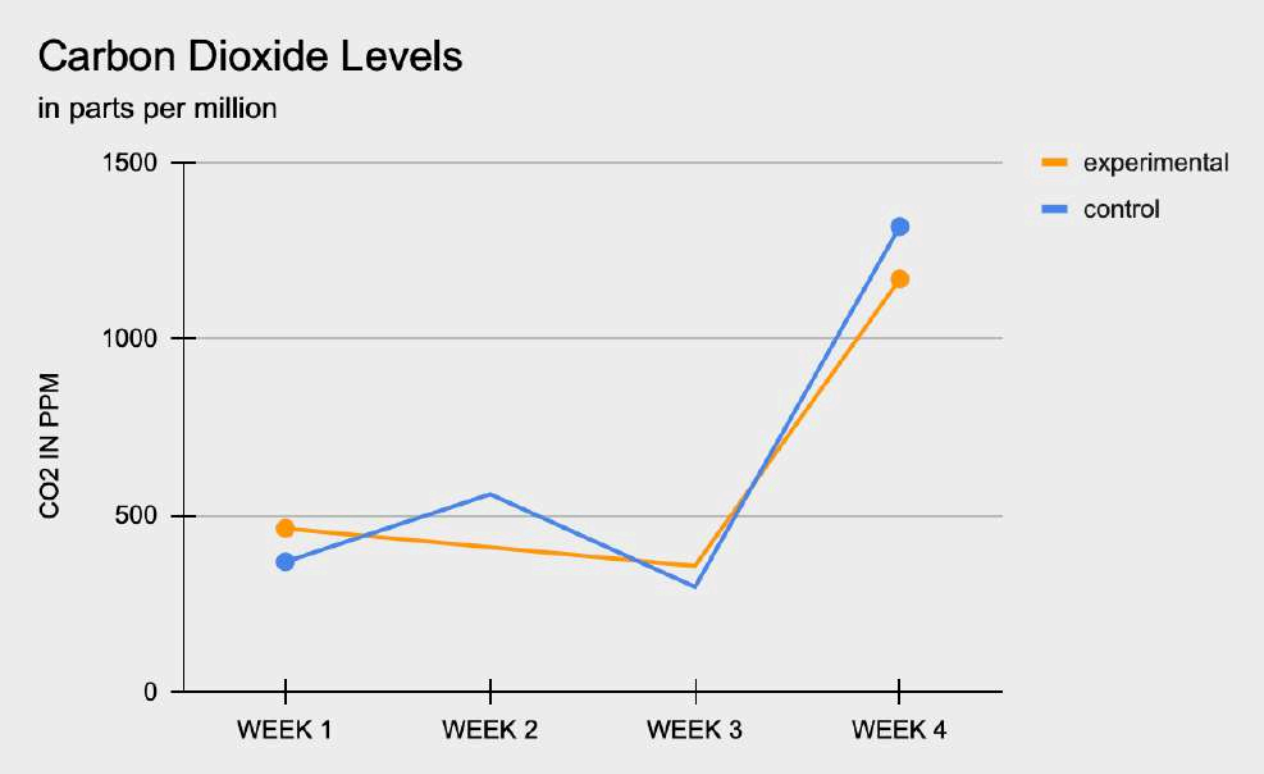
- A two sample T-Test was run to analyze the weekly carbon dioxide levels of each system using Google Sheets and the XL-Miner Analysis ToolPak Extension
- Pictures of the microscopical findings were taken using a phone camera to be compared on a clearer level

How does urban commotion affect crop yield and plant health?

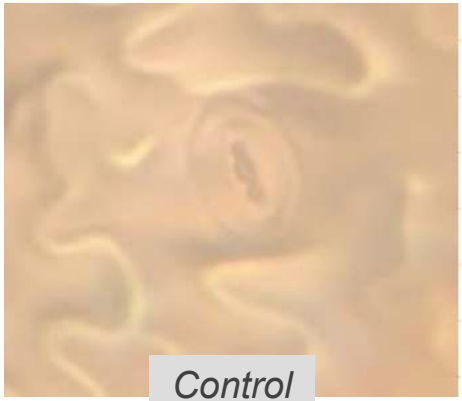
- A chi-squared statistical test was run with a degree of freedom of 4 using Geogebra to quantify the health of each plant in order to find a comparison between the two groups
- A kitchen scale was used to measure the final crop weight of each system

picture of control system during blooming period

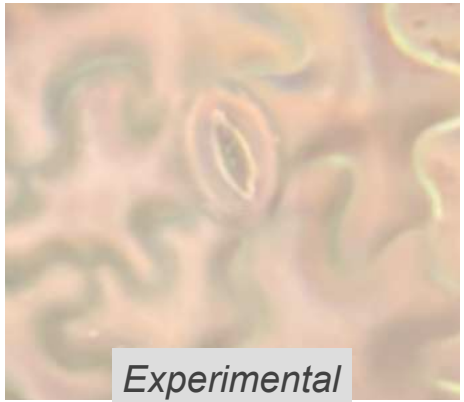
Results: Do city sounds affect a plant's CO2 intake?



P value of 0.905 (p>0.05)



Control



Experimental

Discussion

Do city sounds affect a plant's CO_2 intake?

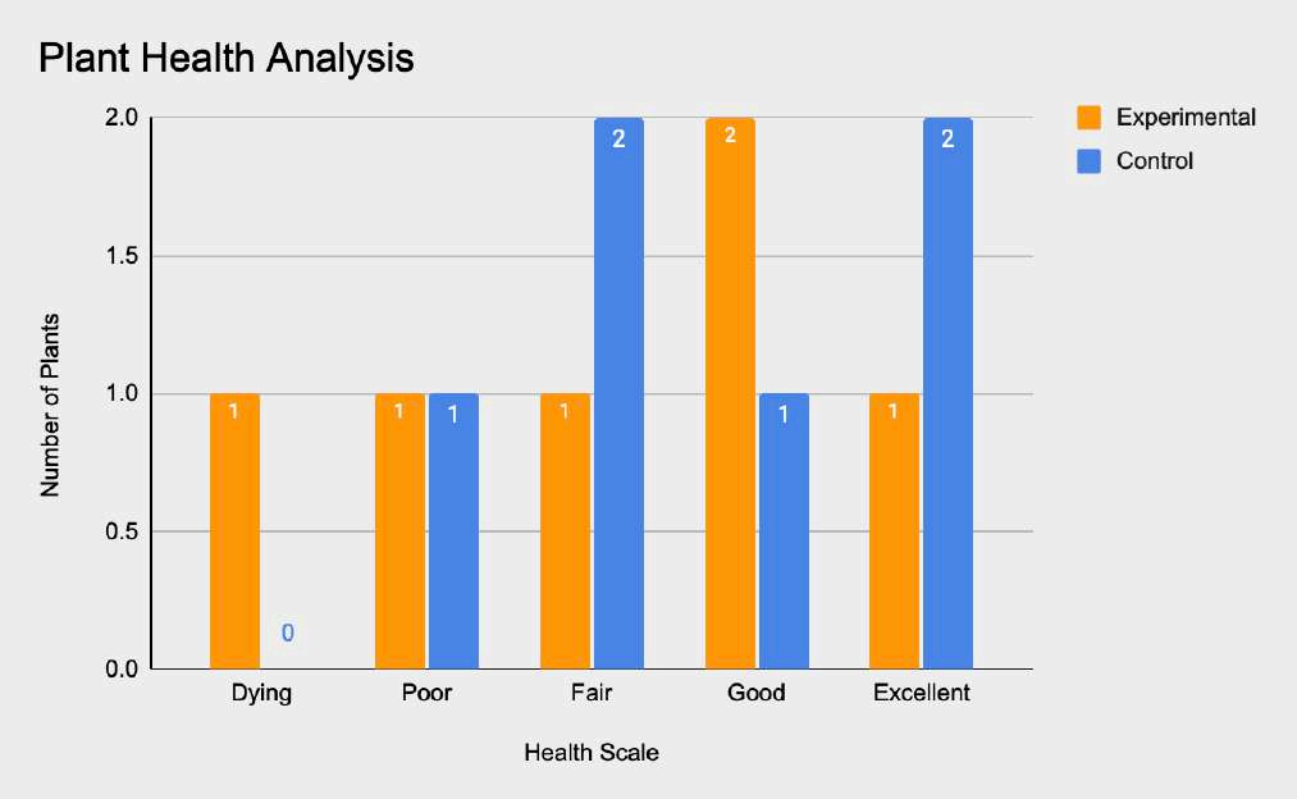
- Based on the results of the t-test, $p>0.05$ hence there was no difference between the two groups meaning the carbon dioxide levels around each system was fairly similar (the addition of sound does not hold an effect).

- 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 airflow 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[4] 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 burn

Results: How does urban commotion affect crop yield and plant health?



P value of 0.7358 (p>0.05)

Final Crop Weight

Control	Experimental
25.8 grams	26.6 grams

Discussion

How does urban commotion affect crop yield and plant health?

- 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 also effected 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 25.8 grams, and the experimental's was 26.6 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

- 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 CO_2 levels.
- Knowing this, cities should continue to implement them throughout vacant spaces 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.

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

References

1. Giro A, Cappellano S, Ferrante A. Vegetable production using a simplified hydroponics system inside City of Dead (Cairo). *Advances in Horticultural Science*. 2016;30(1):23-29. doi:10.13128/ahs-18698

2. CaiWeiMing. Effects of Audio Control on the Growth of Hydroponic Plants. 2013. https://www.dissertationtopic.net/doc/2092482. Accessed October 27, 2020.

3. Nasr G, Darwish E, Sharobeem Y, Abd-Elrahman S. ULTRASOUND IMPACT ON GREENHOUSE LETTUCE PRODUCTIVITY. *Plant Archives*. 2019;19:5.

4. Hendrawan Y, Putra AH, Sumarlan SH, Wojowasito G. Plant acoustic frequency technology control system to increase vegetative growth in red-lettuce. *Telkomnika*. 2020;18(4):2042-2052. doi:10.12928/TELKOMNIKA.v18i4.14158