What Is the Effect Sound Waves Have On Plant Root Physiology and Photosynthesis?

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Photos, graphs, & charts created by student researcher except where noted

Purpose

To analyze the effects of sound pollution in agriculture communities on radish plant chlorophyll levels, stem and leaf growth, and root physiology.

Hypothesis

If growing radishes are exposed to residential neighborhood sound pollution, then chlorophyll levels will fall, lowering photosynthetic efficiency, and reducing the growth height, leaves, and root quality.

Manipulated Variable

- Whether the sample is exposed to sound

Responding Variable

- Percent transmittance on the spectrophotometer, signifying the amount of chlorophyll in radish plants.
- Length and weight of roots
- Width of leaves

Controlled Variable

- Sunlight exposure level is the same
- Plant temperature: 73° Fahrenheit
- Aquarium size: 5 ½ gallons

Experimental Control

- Radishes not exposed to sound

Introduction

Are cars killing our food? My hometown of Sunnyside runs on an agricultural economy, which, according to government data, employs 1831 people yearly. Our county, Yakima, is a national leader in production of apple, wine grapes, and, "the leading county in the nation in the production of hops" (Sallato, 2021).

As our agricultural economy grows, so does our population. As of 2020's census, Sunnyside's population was at 17,105, and growing yearly (Eggers, 2020). Population growth pushes residential neighborhoods farther into surrounding agricultural fields. Could sound pollution from growing neighborhoods harm plant health?

Similar experiments have analyzed the effects of a certain frequency and decibel level on plant growth. These experiments often showed that plants exposed to short sound segments at 100 decibels resulted in positive plant growth. In contrast, my approach uses a sound pattern more typical of agriculture communities: fluctuating decibel level, with the sounds of vehicles, people, animals, machinery, and other agricultural-area sound pollution. This report argues that the sound pollution produced by modern-day agriculture communities is impactful enough to negatively alter plant root physiology and photosynthetic systems in the agricultural economy.

Methodology

Before Measure outdoor decibel levels and record sounds. Create 30 minute recording.

Day 1 Plant 18 radish seeds in 6 planter cups. Divide them evenly in two glass aquariums. Play recording on constant loop in one aquarium at 95 decibels, 3 cm away. Cover both aquariums.

Days 1, 3, 5, 9, 13, 15 Record plant height, and leaf width (widest leaf) every other day.

Day 12 Snip leaves from each radish sample, place in individual test tubes with 10 ml of alcohol. Refrigerate overnight to remove chlorophyll from leaf.

Day 13 Transfer chlorophyll solution to cuvette, place cuvette in spectrophotometer sample compartment, and record chlorophyll percent transmittance level.

Day 15 Measure plant height and leaf width one last time. Remove plants from soil and measure root length and weight.

After Calculate average and standard deviations and analyze patterns.

Results

(Blue number indicates higher level)

Day 7	Height (cm)	Width (cm)
No Sound	.88	.75
Sound	.67	1.73

By day 7, no sound plants grew .21 cm taller. Sound exposure-leaf width averaged .98 cm wider.

Day 13	Height (cm)	Width (cm)
No Sound	2.13	3.7
Sound	2.25	1.41

By Day 13, sound plants-were .12cm higher. Silent plants grew 2.29 cm wider.

Day 15	Height (cm)	Width (cm)
No Sound	2.93	4.38
Sound	2.35	2.43

By day 15, no sound plants grew .58 cm taller. Silent plants grew 1.95 cm wider.

Day 15 Root Weight (grams)	
No Sound	.88
Sound	.67

Silent plants-root weight was.0055 grams heavier.

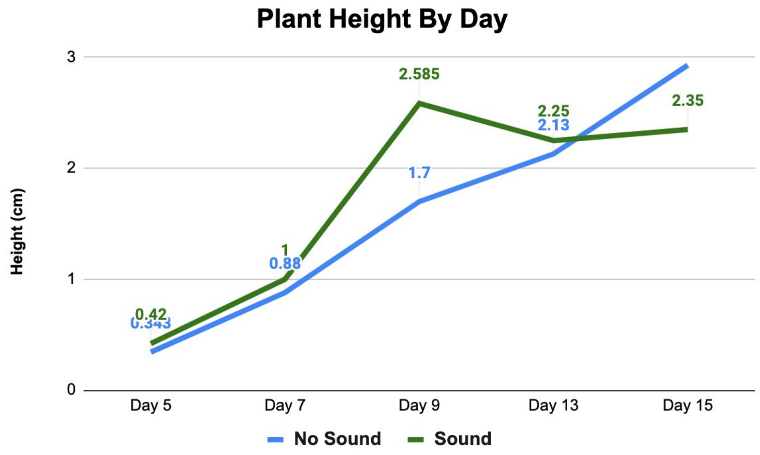
Day 15 Root Length (cm)	
No Sound	4.55
Sound	3.87

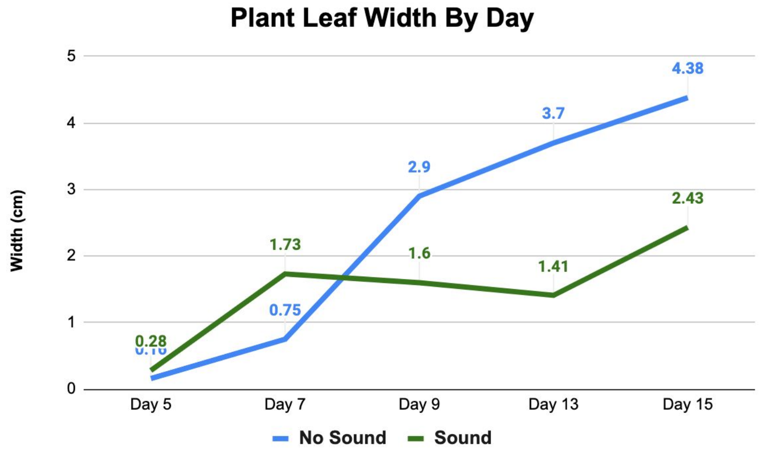
Silent plants grew roots to an average of .68cm longer.

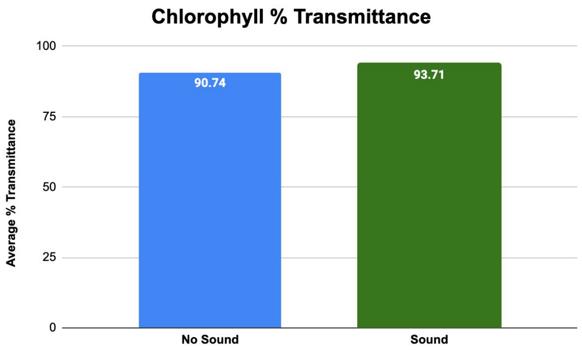
Chlorophyll % Transmittance	
No Sound	90.74
Sound	93.7

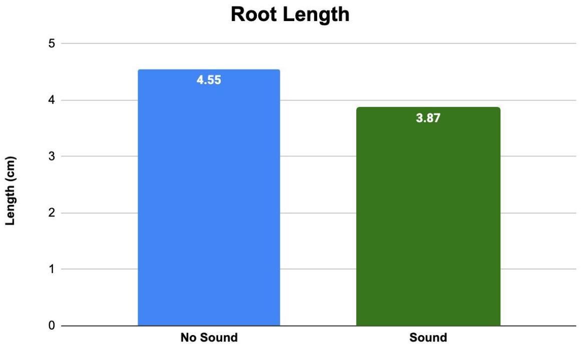
Sound plants had a 2.9% transmission of chlorophyll.

Graphs

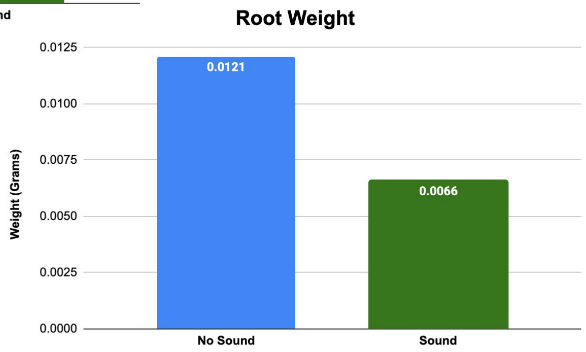








(Higher chlorophyll transmission = plant less healthy)



Radish plant setup: 3 per cup, 18 in total. The black iPad in the aquarium on the right broadcasts sound recordings.

Measuring roots for length after carefully extracting from cups.

Radish leaf sample in 10 ml of water prior to refrigeration.

Using pi-pump & pipette to transfer 5ml chlorophyll solution from test tube to cuvette for spectrophotometer process.

Weighing roots on the scale

Photo credit: Student researcher took first three pictures; parent took final two.

Statistics

Plant Height Day 7	Average (cm)	Standard Deviation
No Sound	**0.88**	**±0.22**
Sound	**0.67**	**±0.23**

Plant Height Day 13	Average (cm)	Standard Deviation
No Sound	**2.13**	**±0.21**
Sound	**2.25**	**±1.08**

Plant Height Day 15	Average (cm)	Standard Deviation
No Sound	**2.93**	**±0.29**
Sound	**2.35**	**±0.97**

Leaf Width Day 7	Average (cm)	Standard Deviation
No Sound	**2.93**	**±0.48**
Sound	**2.35**	**±1.67**

Leaf Width Day 7	Average (cm)	Standard Deviation
No Sound	**2.93**	**±0.18**
Sound	**2.35**	**±0.41**

Leaf Width Day 15	Average (cm)	Standard Deviation
Sound	**2.35**	**±0.74**
No Sound	**2.93**	**±2.44**

Chlorophyll % Transmittance	Average (%)
No Sound	**90.74**
Sound	**93.7**

Root Length	Average (cm)
No Sound	**4.55**
Sound	**3.87**

Root Weight	Average (g)
No Sound	**0.0121**
Sound	**0.0066**

ANOVA Statistics (Analysis of Variance)

Plant Height	The significant difference in no sound plant height occured in cups 1 and 2 on days 9, 13 , and 15. Days 5 and 7 had no statistical difference between the height of sound and no sound plants.
Plant Leaf Width	The only statistical significant difference in leaf width occurred on day 15.
Chlorophyll % Transmittance	There is no statistical significant difference in the % transmission of chlorophyll in 15 days of radish growth.
Root Length	There is no statistical significant difference in root length in 15 days with sound and no sound plants.
Root Weight	There is no statistical significant difference in root weight of the radishes by day 15 with sound and no sound plants.

Conclusion

This experiment investigated how sound pollution from expanding agriculture communities affects plants. I accept my hypothesis that sound pollution negatively impacts plant root physiology and photosynthesis due to plants exposed to sound having lower chlorophyll levels and diminished photosynthetic productivity.

Plant height for trials exposed to no sound recording ("silent plants") were significantly higher than the average radish plants exposed to the sound recording ("sound plants") suggesting that the plant is developing to access light better, resulting in a healthier future. As for leaf width, sound plants were 1.95 cm shorter than silent plants. Sound plants had 2.96% higher transmittance than silent plants, meaning they have lower chlorophyll concentrations in chloroplasts. With regard to root health, the average length for silent plants was .68 cm longer than sound plants. And silent plants' roots were .0055 grams heavier than the sound plants'. Denser, longer roots create stability for the plant, making them more adept at combating inadequate conditions. As a result, the quiet plans should have a significantly more stable, healthy future.

This experiment shows that exposing plants to the clamorous sounds produced by residential neighborhoods reduces plant growth by affecting chlorophyll, leaf, stem, and root physiology. The high decibel level sounds—ranging from 15-112 decibels— limit the synthesization of chlorophyll, a metabolic compound mainly responsible for the pigment and photosynthetic efficiency of a plant. Due to air permeability and surface porosity, sound can pierce through soil undergoing phase change, disrupting the tranquility that roots prefer during initial growth. This, along with lower chlorophyll levels in sound plants, resulted in a difference in root weight and a massive distinction in root length between quiet and sound plants. These results indicate that the effects of sound pollution have a much larger impact on plant's long-term health, as shown in root physiology, than current health, as seen in chlorophyll % transmittance, and plant height, and leaf width.

Discussion

What ideas do you have for expanding or improving this research project?

- Use a larger variety of plants and run the experiment for a longer time period.

- Corn, wine grapes, cherry, apples, and asparagus.

What did you learn? How can your experiment help other people in society?

I learned that sound pollution created by residential neighborhoods negatively impacts plant health. This information contributes to the knowledge available to my region. Considering that the largest industry here is agricultural and that our population is growing, it is important to understand the effects this will have economically and societally.

Trial and Error.

- Spectrophotometer Process:
  - Missing some fingerprints while wiping the cuvette clean.
  - Transmittance control resulting in the digital readout reporting percent transmittance over 100%.

- Root Weighing.

References

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