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Article

Effects of different sound frequencies on the growth of *Phaseolus vulgaris* and *Gaultheria shallon*

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SUMMARY

Plants are important because they are food sources for multiple species, and they help the environment by carrying out cellular respiration and photosynthesis. It has been hypothesized that plants grow at an increased rate when exposed to various music genres. This study examined the level of frequency (1,000 Hz, 5,000 Hz, and 15,000 Hz) that contributes to the highest rate of growth in plants as well as their ability to transpire water. The plants utilized in this study included *Phaseolus vulgaris* and *Gaultheria shallon*. We hypothesized that plants exposed to the most intermediate frequency would have the highest. We also hypothesized that higher frequencies would cause the stomata of the plants to stay open resulting in higher transpiration rates. We calculated transpiration rates of *G. shallon* using a grid method and water loss from a graduated cylinder. We performed our research with two different time periods: a 6.83- (school day) and a 24-hour frequency exposure time. We recorded plant height, stem width, and the number of leaves after 20 days for both plants. Upon analysis, we concluded that the different sound frequencies did not have an effect on plant growth or transpiration rates. Further research is required to fully determine the effects of frequencies on transpiration rates and germination. Increasing knowledge of how to speed up growth periods and transpiration rate by using music could lead to less scarcity of certain plants and a healthier Earth with less carbon dioxide due to increased plant growth and stomatal openings.

INTRODUCTION

Plants are important because they provide food and shelter for wildlife, they help combat climate change and purify the air humans breathe through photosynthesis, they prevent soil erosion, and they promote biodiversity (1). With an increased growth rate, the benefits of plants will be more prevalent. An increase of photosynthesis would likely occur due to an escalated number of plants, leading to a surge in the number of stomata available for gas uptake. During photosynthesis, plants absorb carbon dioxide and water through their stomata. The absorbed carbon dioxide and water will be converted into oxygen and glucose with the help of energy harvested from the sunlight (2). Carbon dioxide is a greenhouse gas that traps heat in the atmosphere, leading to global warming. When carbon dioxide is released, there will more heat trapped in the atmosphere (3). This being said, increased photosynthesis could slowly combat global warming. Next, biodiversity will increase due to increased food sources for animals along with more easily accessible habitats. Lastly, crops would grow faster, and be harvested earlier, leading to a more prosperous food source for humans and other living organisms.

Over the past few years, it has been proposed that plant growth may be enhanced by certain sounds, including music (4). Previous research has shown that high frequencies inhibit plant growth, possibly due to stunting of stomata opening, which interferes with transpiration, an occurrence in plants that allows them to release water vapor through the stomata (5). However, a study completed by the University of Western Ontario discovered that plants grow the best when exposed to a frequency of 5,000 Hz (6). Along with this, previous research has discovered thatwhen introduced to extremely high frequencies such as frequencies above 15,000 Hz, the stomata supposedly have stunted opening rates (7).

Humans are also affected by transpiration rates because when water exits the plant through the stomata, oxygen is emitted into the environment through water (H_2O) during photosynthesis (8). Without adequate transpiration, it is likely that a plant may experience dehydration, which can be detrimental to the plant and its growth (9). Another study examining how sound waves affected rice production methods, specifically the yield of the crops, discovered certain frequencies to be helpful in decreasing drought stress on plants, leading to more healthy plants (10).

Indicators of a thriving plant include a thick stem, greater plant height, and a significant number of leaves, allowing the plant to stand tall and overcome certain challenges (11). A thick stem provides a wide canal for nutrients and water to travel through. When a plant is watered, water enters through the roots and is further distributed via the stem. A greater height is similarly beneficial because it allows the leaves to be closer to the sun. Light energy from the sun helps plants to thrive by providing energy to convert molecules such as carbon dioxide and water into carbohydrates. The increase in carbohydrates helps with the plants' growth, acting as a food source for the plants. The number of leaves on a plant can enhance growth rates and transpiration, as larger quantities of leaves provide higher leaf surface area for more sunlight absorption. Additionally, the increased surface area of a plant increases transpiration due to a greater total number of stomata, allowing more uptake and output of water. Overall, extreme frequencies reportedly have a negative effect on plant germination while average frequencies have no change and support the well-being of the plant (6, 7).

In this study, we used red kidney bean plants (*Phaseolus vulgaris*) because they are fast germinators, easy to grow, inexpensive, and grown as crops, which makes our findings applicable to real world situations. With the goal of making the study more applicable to real world situations, we studied

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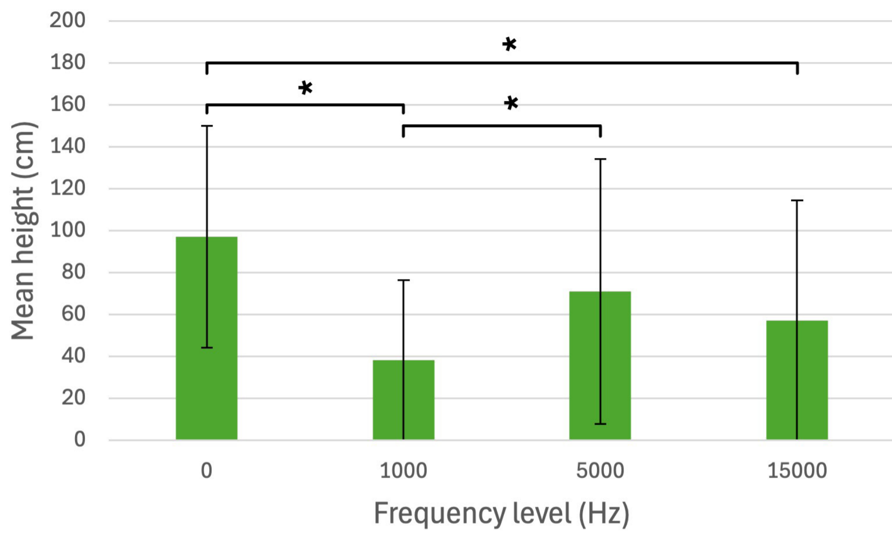

Figure 1. Mean *P. vulgaris* height for each frequency exposure. Bar graph showing the mean plant height of *P. vulgaris* exposed to various frequencies of sound at the end of a 20-day period across two trials. Mean plant heights after 0 Hz, 1,000 Hz, 5,000 Hz, and 15,000 Hz exposure were 97.08 cm, 38.21 cm, 71.01 cm, and 57.16 cm respectively. Error bars represent the standard deviation in the data. "*" represents p-value < 0.05. 1,000 Hz and 15,000 Hz were significant compared to the control (two-tailed t-test, $p < 0.00001$ and $p = 0.01773$ respectively). 1,000 Hz and 5,000 Hz were significant compared to each other (two-tailed t-test, $p = 0.00295$).

transpiration rates in *Gaultheria shallon* (salal plant). We used this plant because of the decently sized leaves and its woody stem. The larger leaves allow transpiration to occur more rapidly. The woody stem was also a factor because they contain lenticels. Lenticels are pores usually found in the stems of woody plants and they are used to transfer gas between the inner tissue of the plant and the atmosphere (12). We did not use *P. vulgaris* when measuring transpiration because their leaves were too small and they did not contain a woody stem resulting in a low level of water loss compared to *G. shallon*. This information could be important when trying to maintain homeostasis within the plant specifically, maintaining proficient transpiration and growth rates.

The purpose of this study was to determine ideal growing environments for crops in terms of sound frequency. Another goal of the study was to determine the effects of differing frequencies on plant height, stem width, and the number of leaves on a plant. We varied the frequencies that plants were exposed to (0 Hz, 1,000 Hz, 5,000 Hz, and 15,000 Hz) and measured change in transpiration rates, plant height, stem width, and number of leaves. Based on past research, we hypothesized that plants exposed to 5,000 Hz would show the most significant growth in plant height, stem width, and number of leaves. This hypothesis was not supported by our data, as plants exposed to a frequency of 0 Hz exemplified the greatest height, stem width, and number of leaves. We also hypothesized that higher tones of sound would cause the stomata of the plants to stay open and allow for the movement of water out of the leaf, resulting in higher transpiration rates. This hypothesis was not supported by our data. In the 6.83 hour trials, plants exposed to 0 Hz had the highest average transpiration rates and in the 24 hour trials, plants exposed to 1,000 Hz had the highest average transpiration rates.

RESULTS

In this study, we examined the effects of various frequencies of sound on the transpiration rates of *G. shallon* and plant growth of *P. vulgaris*. We hypothesized that plants exposed to a frequency of 5,000 Hz would produce higher transpiration rates and a higher growth rate. To test the effects of sound on the growth rates of plants, each group of *P. vulgaris* was exposed to either 1,000 Hz, 5,000 Hz, 15,000 Hz, or 0 Hz (control) for a period of 20 days. We recorded the stem widths, total plant height, and number of leaves. In total, we utilized 160 *Phaseolus vulgaris* plants in this experiment with 100 plants (25 in each group) included in trial one and 60 (15 in each group) in trial two. Plants in both trials were exposed to sound for a period of 20 days. We combined the results from trial one and trial two and checked for statistical significance (*p-value* < 0.05). We tested the *P. vulgaris* data with a one-way ANOVA test with post-hoc Tukey results and the *G. shallon* with a one-way ANOVA test. We further analyzed the results with the application of a two-tailed t-test in order to understand if 5,000 Hz would cause a significantly different transpiration rate and plant growth rate than the other frequencies.

We measured the height of the plants after 20 days of various frequency exposure. Plant height was significantly affected by a change in frequency (one-way ANOVA with post-hoc Tukey test, $p = 0.00031$) (**Figure 1**). Specifically, we concluded that 1,000 Hz and 15,000 Hz exposure resulted in a significantly shorter plant height in the *P. vulgaris* compared to plants exposed to silence (two-tailed t-test, $p = 0.00001$ and $p = 0.01773$, respectively). However, there was no significant difference in plant height between the control and 5,000 Hz treatment group (two-tailed t-test, $p = 0.05677$). The frequency level of 5,000 Hz induced greater plant height in comparison to 1,000 Hz (two-tailed t-test, $p = 0.00295$). In contrast, 5,000 Hz exposure in comparison to 15,000 Hz

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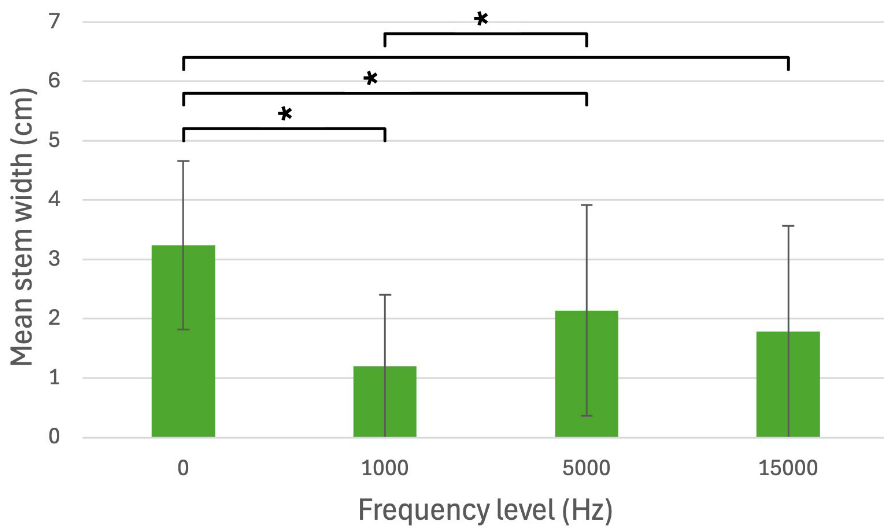

Figure 2. Mean *P. vulgaris* stem width for each frequency exposure. Bar graph showing the mean stem width of *P. vulgaris* exposed to various frequencies of sound over a 20-day period. Mean stem widths after 0 Hz, 1,000 Hz, 5,000 Hz, and 15,000 Hz exposure were 3.24, 1.20, 2.14, and 1.78 mm respectively. Error bars represent the standard deviation in the data. "*" represents p-value < 0.05. 1,000 Hz, 5,000 Hz, and 15,000 Hz were significant compared to the control (two-tailed t-test, p is < 0.00001, p = 0.01405, and p = 0.00069 respectively). 5,000 Hz was significant compared to 1,000 Hz (two-tailed t-test, p = 0.0211).

exposure was insignificant (two-tailed t-test, p = 0.33224) (**Figure 1**).

The stem widths of the *P. vulgaris* were significantly affected by a change in frequency (one-way ANOVA with post-hoc Tukey test, p = 0.00001) (**Figure 2**). Specifically, the results showed that 1,000 Hz, 5,000 Hz, and 15,000 Hz exposure was correlated with a significantly decreased stem width compared to the control (two-tailed t-test, p < 0.00001, p = 0.01405, and p = 0.00069, respectively). In addition to this, 5,000 Hz exposure resulted in a significantly increased stem width in comparison to 1,000 Hz (two-tailed t-test, p = 0.02111). However, results were not statistically significant between 5,000 Hz and 15,000 Hz exposure (two-tailed t-test, p = 0.36306) (**Figure 2**).

Frequency exposure had no statistically significant effect on the number of leaves of the *P. vulgaris* after 20 days of exposure (one-way ANOVA with post-hoc Tukey test, p = 0.22778) (**Figure 3**).

The second species of plant we utilized in this study was *G. shallon*. These plants were used to observe the effects of various frequencies on transpiration rates. We quantified transpiration rates by measuring water loss, time of frequency exposure, and leaf surface area. We utilized 72 *G. shallon* plants in this experiment with 48 plants exposed to different

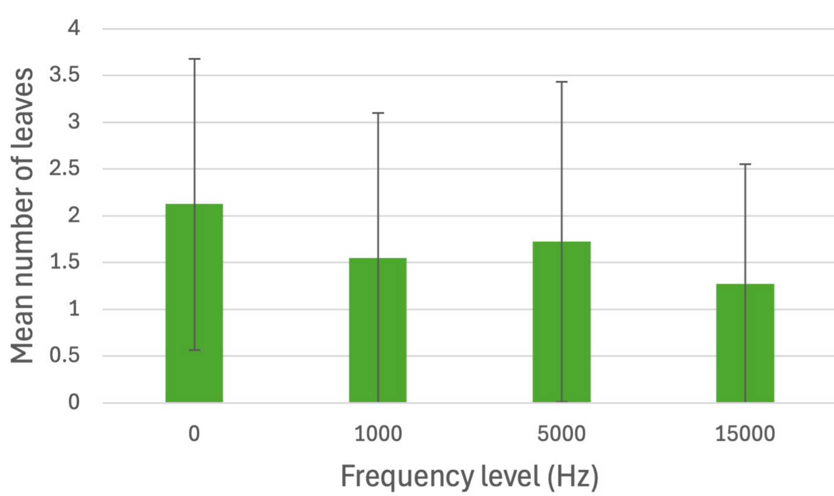

Figure 3. Mean number of *P. vulgaris* leaves for each frequency exposure. Bar graph showing the mean number of leaves of *P. vulgaris* exposed to various frequencies of sound over a 20-day period. Mean number of leaves after 0 Hz, 1,000 Hz, 5,000 Hz, and 15,000 Hz exposure were 2.12, 1.55, 1.72, and 1.27 leaves respectively. Error bars represent the standard deviation in the data. The mean number of leaves was not significant (one-way ANOVA test, p = 0.22778).

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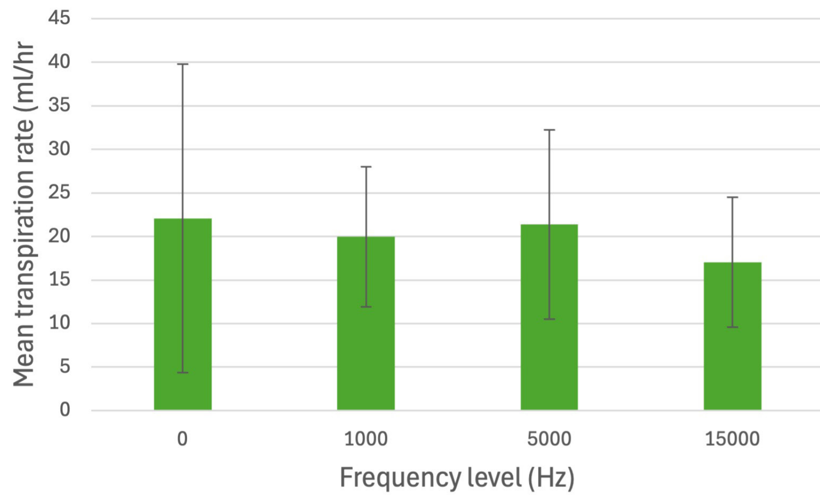

Figure 4. Mean *G. shallon* transpiration rate across for each frequency exposure. Bar graph showing the mean transpiration rate of *G. shallon* exposed to various frequencies of sound for 6.83 hours. Mean transpiration rates after 0 Hz, 1,000 Hz, 5,000 Hz, and 15,000 Hz exposure were 22.07, 20.36, 20.98, and 17.03 ml/cm respectively. Error bars represent the standard deviation in the data. Mean transpiration rate was not significant (one-way ANOVA test, p = 0.72826).

frequencies for 6.83 hours (3 plants in each designated room per week for four weeks) and 24 *G. shallon* plants exposed for 24 hours (3 plants in each designated room for two weeks). The effects of various frequencies on the transpiration rates of the plants with 6.83 hours of exposure were not statistically significant (one-way ANOVA test, p = 0.72826) (**Figure 4**). Exposure to different frequencies also had no significant effect on plant transpiration after 24 hours of continual exposure (one-way ANOVA test, p = 0.99146) (**Figure 5**).

DISCUSSION

This study examined the various effects of differing sound frequencies on *P. vulgaris* and *G. shallon*. We hypothesized that a frequency of 5,000 Hz would result in greater plant growth and higher transpiration rates. However, we concluded that exposure at 1,000 Hz, 5,000 Hz, and 15,000 Hz were associated with a significant decrease in plant growth when compared to silent exposure (0 Hz, control).

We noticed plants exposed to 5,000 Hz also resulted in a slightly taller *P. vulgaris* height compared to exposure at 1,000 Hz and 15,000 Hz. These results can be verified with more trials considering that the *p*-value was 0.05677, which is very close to the significance level. Other studies have shown similar benefits of exposure to 5,000 Hz in comparison to lower and higher frequencies (13). Specifically, in a study conducted at the University of Western Ontario, researchers had observed that the surface area of plants increased the most when exposed to 5,000 Hz (6). Plants have also

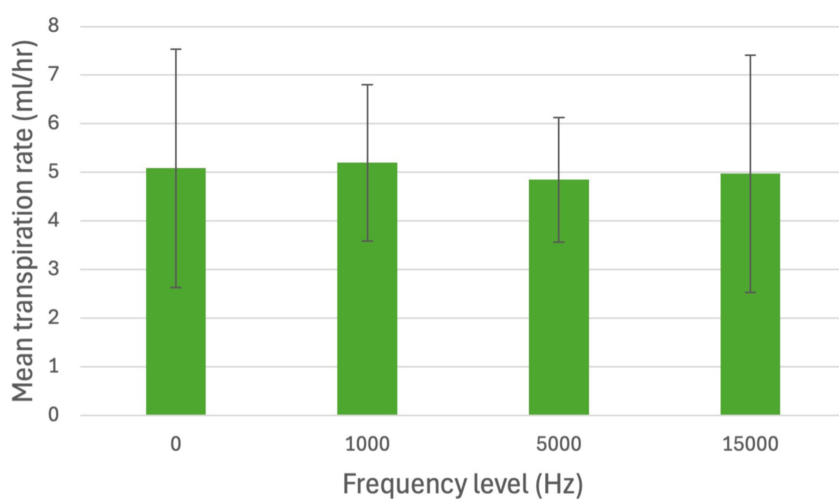

Figure 5. Mean *G. shallon* transpiration rate for each frequency exposure. Bar graph showing the mean transpiration rate of *G. shallon* exposed to various frequencies of sound for 24 hours. Mean transpiration rates after 0 Hz, 1,000 Hz, 5,000 Hz, and 15,000 Hz exposure were 5.10, 5.19, 4.84, and 4.97 ml/cm respectively. Error bars represent the standard deviation in the data. Mean transpiration rate was not significant (one-way ANOVA test, p = 0.99146).

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responded differently when subjected to random noise, which might correlate more to the sound of people talking than any pure tone would (6). However, further research would need to be conducted to confirm how random noise might affect the stem width and height of the plant.

In addition to plant growth, we hypothesized that exposure to 5,000 Hz frequencies would result in a greater transpiration rate in *G. shallon* due to greater opening rates of the stomata. An increased surface area as a result of sound exposure would directly affect the rate of transpiration due to the presence of more increased stomata (6). However, the results of our study did not support a relationship between frequency of sound and the transpiration rates in *G. shallon.*

Our experiment was limited primarily by the usage of only certain, accessible materials as well as time in the lab. To measure the means of transpiration of the plants, we had originally proposed the usage of a potometer. The potometer is an instrument used to measure the rate of water intake by a plant by observing how far an air bubble moves along a capillary tube as the plant absorbs more water. However, we struggled to introduce the air bubble into the capillary tube and exhausted all other efforts in attempts to execute it. Finally, we decided to use graduated cylinders to measure transpiration instead. As a result, we had less time to gather more data for plant growth and transpiration.

If this study were to be replicated, we recommend that a better procedure regarding the measurement of transpiration rates is utilized such as the use of a potometer. In addition to this, we recommend that the *P. vulgaris* are watered more frequently than every four days, as many of the plants showed signs of dehydration and the soil was not as moist as it should have been. For future studies, we recommend watering *P. vulgaris* every 1–3 days depending on environmental conditions such as temperature and type of soil. This is especially important if one chooses to use a heating pad to regulate plant temperature. We also suggest that a different source of technology be utilized to play the frequency, instead of computers, which were used in our study. This is recommended due to multiple instances in which our computers had shut off unknowingly and the frequencies playing from the computer had stopped. Finally, we recommend that two more trials be conducted, especially regarding 5,000 Hz exposure. More trials and time available to conduct the study would be important in ensuring more accurate results.

The application of frequency of sound could be utilized in attempts at achieving larger plant height and overall plant growth. Specifically, this could aid horticulturalists in their care for plants and achieving preferred conditions for growth. More research should be done to observe this effect further. Researchers can utilize a different agricultural crop, find a different way to measure growth or transpiration, or observe other factors that affect transpiration and plant growth. The use of important agricultural crops such as corn could be used in further studies to test optimal growing conditions for agriculturalists. More applications of this effect could also be observed by further research in attempts to confirm the effects of large-scale frequency exposure on crops included in farming as well as less costly ways to apply it.

MATERIALS AND METHODS

Groups of 25 *P. vulgaris* plants were grown in 4 rooms with consistent conditions containing 84 LED plant lights on an 8 hour timer, plant heating pads, noise stoppers underneath the doors, and foam padding attached to the back of each door. *P. vulgaris* plants were planted in groups of five each day. The planting was done by taking a plastic, 2.7 x 3 inch pot, filling it halfway with Miracle Grow Garden Soil, placing a seed in the middle of the pot, and then filling the rest of the pot with soil. After each pot was filled with dirt, it was given 20 mL of water. Watering took place every four days. The newly potted plants were then distributed to their rooms. We placed 25 plants in each of the 4 rooms. In their respective rooms, plants were exposed to frequencies for a total of 20 days (**Figure 6**). The frequencies in each room were randomly selected. Frequencies consisted of 0 Hz, 1,000 Hz, 5,000 Hz, and 15,000 Hz. Frequencies were played through an online tone generator. Tones were played for 6.83 hours per day in each

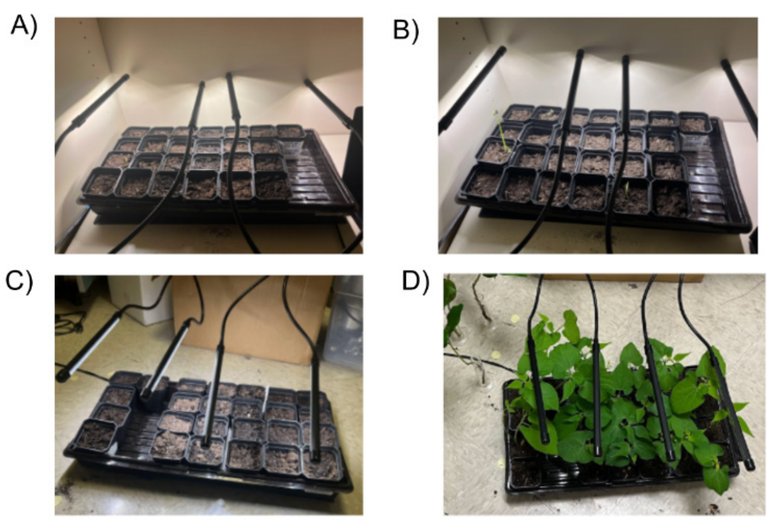

Figure 6. Trial one of 25 plants exposed to 1,000 Hz and 0 Hz. A) Before exposure to frequency of 1,000 Hz in comparison to **B)** after 20 days of exposure. **C)** Before exposure to 0 Hz in comparison to **D)** after 20 days of exposure.

room except the control room, where no sound was played. After being in their respective rooms for 20 days, the stem width, plant height, and number of leaves were recorded.

A second trial was later conducted over 15 days. The set-up of the rooms and watering schedule stayed consistent with the first trial. However, the frequencies in each room changed. During this trial, we started the second part of our project involving transpiration rates. We used shoots from the plant *G. shallon*. For the 6.83 time period, 12 shoots of *G. shallon* (3 in each frequency group) were included and in the 24-hour time period, 6 shoots (3 in each frequency group) were included.

The set-up for each room remained the same as in the plant growth trials. The ends of the shoots were cut with a paper slicer. Four graduated cylinders filled with 20 mL of water were placed in each of the 4 rooms and plants were placed in 3 out of the 4, with one cylinder in each room acting as a control.

The first trial with transpiration consisted of the plants being exposed to frequencies for 6.83 hours. After 6.83 hours, we recorded the amount of water left in each graduated cylinder and re-filled the cylinders. Trials with one crop of *G. shallon* lasted one week before we discarded the shoots and purchased new ones. At the end of each week, we measured the surface area of the leaves on each *G. shallon shoot*. To measure the total surface area for one shoot, we compared each leaf on a stem to levels that we created. To do this, we chose five leaves of varying sizes from the original G. *shallon* and traced the leaves onto one centimeter grid paper. Each square completely inside of the tracing equaled one square centimeter. Each square not completely enclosed in the tracing that still had a pencil mark over it counted as one half of a square centimeter. Each leaf on a G. *shallon* plant was then matched with the key closest to its size and counted as the area that correlated with the key. The area (cm^2) from each level was then summed for each leaf on a stem to find the total surface area of a shoot. We then calculated the total transpiration rate for each shoot. The equation used for calculating the transpiration rates was (20-mL)/ (hrs)/ (cm^2)*(10,000). The results from the equation were in mm^2/h. The 10,000 acted as a constant so the values being compared were larger.

We later conducted transpiration tests with 24-hour exposure; however, the computers that we used to play the frequencies did not respond well to the 24- hour exposure period and some would often shut off. Because of this, some of our data was not applicable to use in the results of our study.

Amount of Plant Utilized

One hundred (25 in each frequency group) shoots of *P. vulgaris* were included in the first sample and 60 (15 in each frequency group) were utilized in the second sample. Twelve shoots of *G. shallon* (3 in each frequency group) were included for the 6.83 time period per week over 4 weeks and 12 shoots (3 in each frequency group) per week over two weeks were included for the 24-hour time period.

Plant Conditions

The lights used were put on an 8-hour timer. Plant heating pads were placed underneath plant trays and set to 75°F. The conditions were the same for every room. Plants were given 20 mL of water every 4 days starting the day after being planted. Plants were not watered on weekends. If a watering day fell on a Saturday or Sunday, they were given their respective 20 mL on the closest weekday.

Plant Height and Stem Width Measurements

Plant height and stem width were measured with a digital caliper in millimeters. The number of leaves on a plant were hand counted. To measure the surface area of *G. shallon*, leaves were matched with a key based on size. Leaves that matched with level one counted as 18 cm^2, level two counted as 25 cm^2, level three counted as 33.5 cm^2, level four counted as 40 cm^2, and level five counted as 50.5 cm^2, respectively. Along with these levels, any leaves less than half the size of the level one key were recorded as 0 cm^2.

Statistical Analysis

P. vulgaris was used to determine the effects of varying frequencies on plant height, stem width, and number of leaves. To calculate this, we used a one-way ANOVA test with post-hoc Tukey through the Social Science Statistics Calculator (14). *G. shallon* was used to observe the effects of various frequencies on transpiration rates. To calculate statistical values regarding transpiration rates, we used a one-way ANOVA test through the Science Statistics Calculator (14).

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REFERENCES

1. "Why are Plants Important? 7 Reasons Why We Need Them" *Woodland Trust.* https://www.woodlandtrust.org.uk/blog/2024/06/why-plants-are-important/. Accessed 4 Jan. 2026.
2. "The Process of Photosynthesis" *Monash University.* https://www.monash.edu/student-academic-success/biology/photosynthesis/the-process-of-photosynthesis. Accessed 4 Jan. 2026
3. Fetch, Sarah. "How Exactly Does Carbon Dioxide Cause Global Warming" *State of the Planet*, https://news.climate.columbia.edu/2021/02/25/carbon-dioxide-cause-global-warming/, Accessed 4 Nov. 2023.
4. Jung, Jihye, et al. "Beyond Chemical Triggers: Evidence for Sound- Evoked Physiological Reactions in Plants" *Frontiers In Plant Science,* vol. 9, Jan. 2018, https://doi.org/10.3389/fpls.2018.00025.
5. Knight, R.C. "'Relative Transpiration' as a Measure of the Intrinsic Transpiring Power of the Plant." *Annals of Botany,* vol. 31, no. 123/124, 1917, pp. 351–359, https://doi.org/10.1093/oxfordjournals.aob.a089652
6. Collins, Margaret E. and John E.K. Foreman. "The Effect of Sound on the Growth of Plants.*" University of Western Ontario, London, Canada* vol. 21, no. 2, 2001, pp. 3–8
7. Vian, Alain et al. "Plant Responses to High Frequency Electromagnetic Fields". *BioMed Research International*,

https://doi.org/10.59720/24-179

2016, https://doi.org/10.1155/2016/1830262.

8. Hagan, Eva. "How trees make oxygen, and other ways they are vital to human existence". *World Economic Forum*, https://www.weforum.org/stories/2022/12/trees-oxygen-human-existence-climate-change/#:~:text=Trees%20convert%20 carbon%20 dioxide%20and,the%20effects%20of%20 climate%20change, Accessed 4 Nov. 2023.
9. Broughton, Katrina J. and Warren. C. Conaty. "Understanding and Exploiting Transpiration Response to Vapor Pressure Deficit for Water Limited Environments." *Frontiers in Plant Science,* vol. 13, no. 893994, 2022, pp. 1–12, http://doi.org/10.3389/fpls.2022.893994.
10. Jusoh, Mashitah et al. "Specific Sound Frequency Improves Intrinsic Water Efficiency in Rice Leaf by Imparting Changes in Stomatal Dimensions." *Pertanika Journal of Tropical Agricultural Science,* vol. 46, no. 2, 2023, pp. 439–457, https://doi.org/10.47836/pjtas.46.2.05
11. "How to Interpret Plant Growth Patterns". Live to Plant. https://livetoplant.com/how-to-interpret-plant-growth-patterns/. Accessed 4 Jan. 2026
12. Carrilo Lopez, Armando and Elhadi M. Yahia. "Morphology and Anatomy" *Postharvest Physiology and Biochemistry of Fruits and Vegetables* edited by Elhadi M. Yahia, 2019, pp. 113–130.
13. Lee Ying, Joanna et al. "Experimental Investigation on the Effects of Audible Sound to the Growth of Escherichia coli." *Modern Applied Science,* vol. 3, no. 3, 2009, pp. 124–127, https://doi.org/10.5539/mas.v3n3p124.
14. "Statistics Calculator" *Social Science Statistics.* https://www.socscistatistics.com/tests/. Accessed 4 Jan. 2026
15. "Microsoft Excel" *Microsoft.* https://excel.cloud.microsoft/wdOrigin=MARKETING.EXCEL.OPEN. Accessed 25 Feb 2024
16. "Google Slides: Online Presentations for Business | Google Workspace". *Google.* https://workspace.google.com/products/slides/. Accessed 25 Feb. 2024