How do sounds of varying frequencies affect the growth of plants?

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INTRODUCTION

It is often said that the youth of the 60's and 70's were mainly interested in three things: sex, drugs, and rock and roll. This time period spawned revolutions in all of these fields. There was also a new group of people who believed two of these interests could be combined. These people believed that music could increase growth of plants, especially marijuana (Cannabis Sativa).

There have been many studies relating to sound and the growth and health of plants and animals, including human beings. For example, the Department of Public Health in Helsinki, Finland published a study in 2006 entitled "The Association of Noise Sensitivity with Coronary Heart Failure and Cardiovascular Mortality among Finnish Adults." This study investigated every pair of identical twins in Finland born in 1958 with both twins living in 1967. They received questionnaires which helped them determine the level of noise sensitivity the subject had as well as estimating the amount of noise they had been subjected to over their lives, such as noisy homes (near industries such as railroads), noisy occupations, and noisy hobbies. They then compared noise sensitivity, gender, and amount of noise exposure. It was found that women who were noise sensitive, and had been subjected to more noise than others, were at high risk for heart problems. Therefore, noise sensitivity either is a risk factor or may be used as a risk indicator for heart problems (Heinonen-Guzejev).

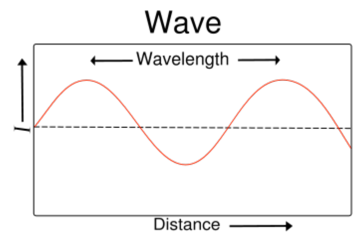
It has been hypothesized that sound increases growth in plants, and some companies even use a growth system that incorporates sound to try to increase growth (High Times). Thus, sound could effectively increase the amount of marijuana, or any plant, that you could grow. In these cases, sound was desired and potentially beneficial. In other cases, the unwanted effects of sound on plants, or the environment, are referred to as noise pollution. For example, it could create effects very similar to eutrophication, which is when the environment promotes growth that it cannot support. This can have a long term effect on the world's environment. It doesn't sound like much, but after years of noise from everything from music to leafblowers to cars to subways, there could be a significant growth in plants. This could also be caused by a limited local burst in the supply of nutrients, such as food, nitrogen, etc. This would lead to more animals feeding off the plants. Larger and more plentiful plants and animals need more nutrients to survive. However, there is a limited supply of nutrients. This could cause anything from localized plant death to even mass extinction, due to plants not getting the nutrients they need. Then, the animals that eat these plants would not have enough to eat, and neither would the carnivores who eat them.

Of the many sources of pollution and environmental danger, noise pollution is one of the least talked about. That may be why it is one of the most dangerous. It has the power to damage hearing, cause dizziness and nausea, and cause various other kinds of damage to the human body. There is also speculation about noise pollution's harm to the environment. If more was known about the effects of noise pollution, however, it would be possible to know exactly how noise effects the environment, and at what frequencies, making it possible to enact laws limiting noise pollution specifically and with greater effect, and to learn how much noise is dangerous to humans and the environment. One way to learn this is to see how sound affects plants, and comparing it to possible effects on humans. **This experiment hypothesized that higher frequency will affect the ability of plants to perform their functions, resulting in greater growth.**

BACKGROUND RSEARCH

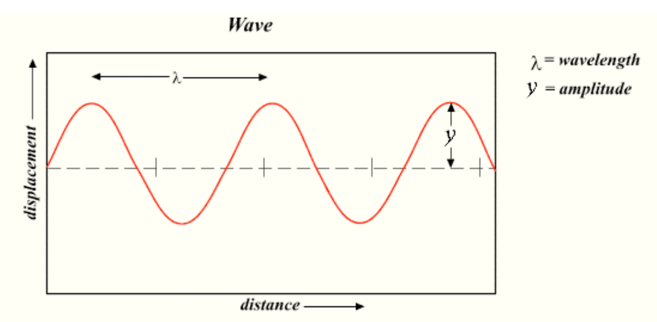
The fundamentals of this test require a basic knowledge of both sound and plants. Sound is defined as "…mechanical energy in the form of pressure variances in an elastic medium. These pressure variances propagate as waves from a vibrating source. " (Blair School of Music). It is essentially a sort of wave of vibration that disturbs still matter. What we can hear and normally associate with the word "sound" is our perception of these waves through our ears. Sound is characterized by many factors, the most important of which are wavelength, period, amplitude, speed, and frequency.

Wavelength is the length between two waves in sound. Sound travels in the form of a varying wave, interpreted by humans as a single, solid sound. Wavelength is graphed as the distance between 2 peaks (Blair School of Music). The image to the right shows the wavelength on any given wave.



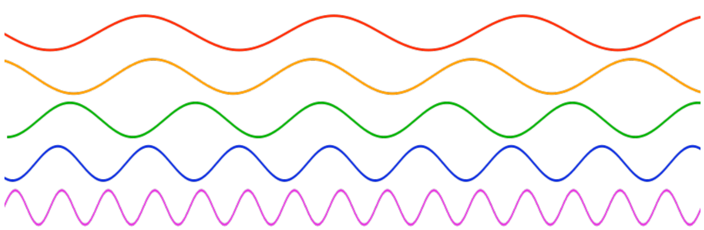
Period is generally defined as the amount of time something takes to complete one cycle. In sound it is essentially the same thing as wavelength, except wavelength is expressed as a distance, whereas period is a time (Truax).

Amplitude is the maximum disturbance a wave has from neutrality. It will be important in this test to keep amplitude completely stable. It is graphed as the height of a peak. The image below shows the wavelength compared to the amplitude (Blair School of Music).

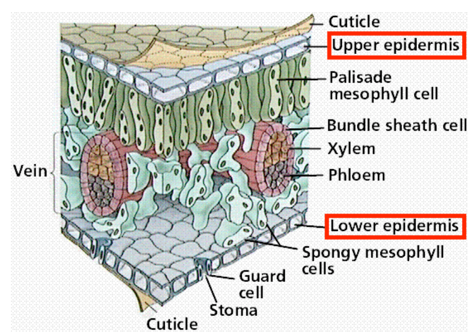


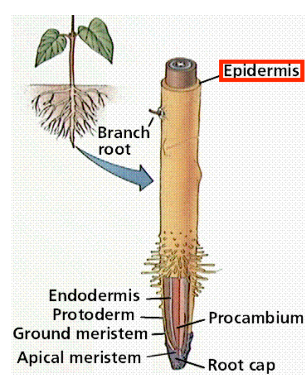
Speed of sound describes the speed at which sound waves move through matter. However, this changes based on the type of matter, and many other factors. Therefore, it is commonly expressed in terms of speed through dry, ground level air, aproximated by v= 331 m/s + (0.6 m/s/C)*T. “T” is air temperature in °celsius. Therefore, the speed of sound at this temperature is 34 meters/second, about 750 mph, which is relatively low compared to other waves, such as light ("Speed Of Sound.").

The final measurement of sound is frequency. Frequency is similar to wavelength, the standard use of period, and speed. It is essentially the amount of times a wave occurs in an area over a given amount of time. It is equal to the speed divided by the wavelength. The image to the left shows waves with varying frequencies. Therefore, speed and wavelength both go into forming the frequency. The frequency is a function of the two.



Plants interact with their outside world through epidermal cells. This is a group of cells that form an outside barrier to the plant. These are shown in both pictures to the right. The one below shows the stem, and the one above shows the leaf.





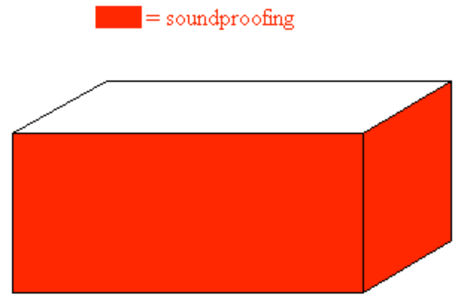
Gasses are exchanged through gaps in these cells, which contract and expand like pores. There is also a collection of cells within this barrier that form the bulk of the leaf. These house chloroplasts and perform the main chemical functions of plants.

It is thought by some that plants can perceive aspects of the outside world. However, this does not happen in a central nervous system as with humans. It happens on a cellular level ("Plant perception (physiology)."). This is NOT perception as we normally use the word. Every disturbance, whether its sound, light, gravity or magnetism, is on a microscopic level a physical disturbance in the natural air. Sound is in the form of physical waves that have the potential to crash into objects, such as plants or plant cells, and damage them. The theory is that as each cell is blasted with waves of sound, light, and so on, it alters the amount of RNA created (Xiujuan et al. 2-3). I believe this will lead to greater growth.

One example of this is a study conducted by the key lab of biochemical studies for the Ministry of Education of the People's Republic of China. This study exposed chrysanthemum flowers to high levels of sound and measured the DNA and RNA produced by the cells. There was a significant increase in the levels of RNA.

METHODS

The first step to this procedure is to acquire the plant subjects, and note their normal growth. We chose basil because it grows fast and you can quickly see any change. Because we performed this experiment in the winter and early spring, we couldn't get a flat of basil, which has enough already grown plants to do the experiment many times. Therefore, we planted seeds in a growing medium and germinated the basil under a growlight. There was a scale implanted in the soil of each plant, as shown above.



Next we placed the plants in five separate soundproof containers. Four of them also contained a Mac Ibook, through which we played the sound (we did not actually have the plant wearing headphones). The other container was the control, which had no sound playing in it. Each plant had the same light source, as well being controlled for other variables, because they were all in the same location with the same exposure to sunlight. In addition, we performed the experiment in the 7th floor prep room, where it was not often disturbed, and variables could be easily controlled. Each of the cases actually had three plants, which will sort of act as three trials. However, because we ran the experiment twice, and have 2 trials of the total experiment, we will refer to these as plants (plant 1, plant 2, plant 3), and to cases as frequencies. So, plant 1 on the control would be "control 1", or on 1140hz would be "1140hz 1".

The test ran for two weeks. Each day at 11:20 we measured the plants in centemeters, watered the plants and turned on the sound. We also took a photo of each plant for later use. Each subject was exposed to a different sound. The frequencies of the sound waves were 440hz, 1140hz, 2440hz, and 3440hz. We also took a picture of each plant, from the side. At 3:20 pm we turned off the sound, adding all information to our data tables. We then turned off the iBooks to recharge for the next day.

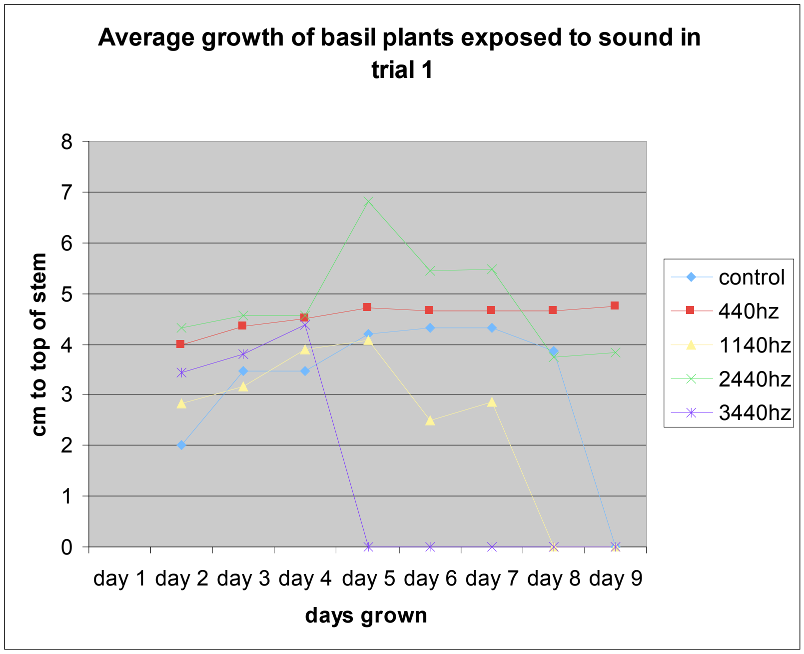
For trial 2 we changed the position of the tanks, to ensure that each one was completely soundproof, and then tested each one. We also changed the amount of time they were exposed to sound, so we started the experiment at 12:15, and ended at 2:45, with a 2.5 hour exposure time. We also changed the wattage of the growlight bulbs from 75 to 50. This was because one of the reasons the plants died so quickly in the first trial was from the roots overheating and burning.

A plant was considered dead when it had lost all green color, wilted, shrunk, or shriveled, and was unable too support itself.

RESULTS

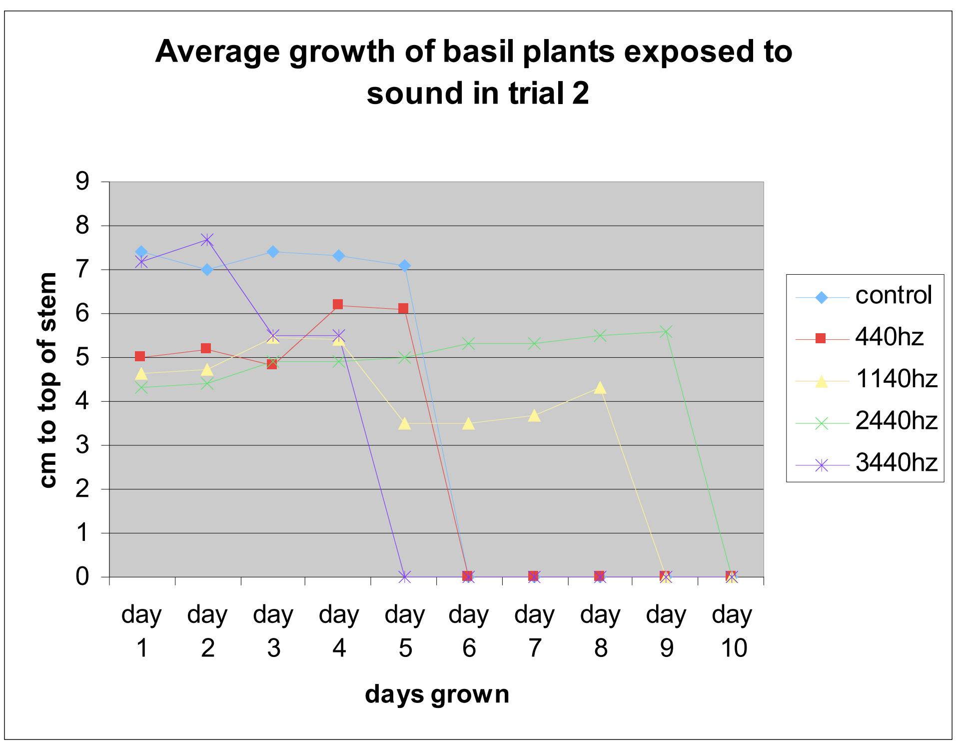
In these graphs, a measurement of 0 indicates a dead plant. Also, decline in height could be due to, or interpreted as, wilting or decay.

FIG. 1



This graph shows the average growth for three different plants during trial 1.

FIG. 2



This graph shows the average growth for three different plants during trial 2.

CONCLUSION

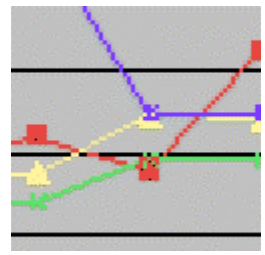
The data suggests a few different things. It does not necessarily prove or disprove my hypothesis. Instead it suggests that it is not as simple as saying that a higher frequency is better for plants. Rather, there is a healthy range of frequencies, somewhere around 2400 Hz.

It also suggests that the growth of a plant does not have a direct equivalency to health. Most of the cases grew more rapidly at the beginning, but quickly got brown and dry, indicating they were not healthy.

The final thing it suggests is the way increased RNA production could help plants. As stated earlier, having a sound frequency aids in the production of RNA in plants (Xiujuan et al. 2-3). However, I interpreted that as not having a direct connection to growth. Instead, in this case it seems to make the plant better able too maintain itself. It is possible that RNA helps regenerate cells at a more even rate, helping the plant replace lost cells.

Figure 1 shows the average growth for three different plants during trial 1. This data is not very conclusive, because the growth rates within a specific given condition varied greatly, and all plants died very quickly. In addition, there were some problems with the experiment, so we started a new trial, but changed it (see methods for changes).

Figure 1 shows the average growth for three different plants during trial 2. In making this graph we averaged the three plants in each condition. However, in this trial most conditions only had two plants, because not all of the basil had actually grown. In this trial, most cases had at least one dead plant fairly quickly. So, when we made the original graph, we counted the plant as dead when only one plant remained. However, this information does not give us enough to analyze, and seems to suggest that the plants all died very quickly. This is misleading, because at times these remaining plants were quite healthy. Because of this, in the graph for trial 2 I included data where only one plant remained alive, which shows a more accurate representation of the outcome of the experiment. This explains the situations where a line on the graph lowers and then rises again. In these cases, such as 440hz around day 3 (the red line in the image at right) one of the two plants was dying, lowering the average, but once it died the average reverted back to its healthy counterpart.



This can give you a better idea of my results. Note that while 440 Hz was the only one that had any period of significant growth, that may have been due to the death of the first plant. Before, when there were two plants, the shorter one kept the average from getting too tall. But, once that plant died, the average was only the second plant, and the second plant's greater height showed itself in the data.

There are no plants that exhibit any sudden significant increase in growth. However, there is one plant that shows constant health and growth. This is the plant under 2440 Hz of sound. It shows a consistent growth of about 1 cm over a period of nine days, and is the longest living plant. In addition, there are two observations that are not expressed by this graph 2. The first is that until day ten, when it had died overnight, this plant was considerably healthy. By that I mean it had wide, strong leaves, which were able to support themselves, as well as a thick, sturdy stem, and a bright green color, darker in the leaves and lighter in the stem. Therefore, this was definitely the healthiest of all the plants. The second observation is that there was another plant which is not included in the data. As seen in the picture at right, the plants were planted in trays of 6. We measured only the first three, just so that we didn't have too much data. However, in this case, the extra plant exposed to 2440 Hz was in fact the only one to survive after these ten days, and had recently grown to be very big. It has a strong stem, huge leaves, and a great green color. This is evidence that this is the optimal frequency for the health of plants.

The one main problem with our experiment, though, was that it could not be truly accurate because of our limited equipment and space. It would be more accurate if we had a large space where we could set up five completely soundproof containers, each with completely accurate synthetic environments of which we could control and keep constant every aspect. We did not have that space, though, and the test was not completely accurate. However, for the purposes of testing the effect of sound and getting a general idea of the results, the experiment works as it is.

Some more scientific investigations might ask how different aspects of music effect plants, such as beat or pulse, or rhythm in music; volume, or even different types of music (e.g. Metal, punk, rap, classic rock, jazz, classical, speed metal…)

Sound is important in other ways than merely contributing to the environment. For example, sound effects the way humans think and feel. As stated in "Sustainable Soundscapes: Noise Policy and the Urban Experience",

> The environment is mediated through all our senses, and yet more attention is paid to the visual experience… and how can we evaluate that sound experience?… they may be classified according to their function

> and meaning, or according to their emotional or affective qualities (aesthetics). (Adams, 2385-2386)

In other words, this investigation merely scrapes the surface of the noise topic.

There is so much we do not know about the human psyche. Because of this, there is so much to learn about sound, including how it affects humans in ways other than just bodily.

One thought for consideration might be how music affects humans, emotionally, socially, and politically. For example, how is sound included in our laws or culture?

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