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The Effect of Sound Waves at Different Frequencies upon the Plant Element Nutritional Uptake of Snake Plant (*Sansevieria Trifasciata*) Plants

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Abstract

Objectives: The objective of this study was to determine how different sound frequency values effect on plant growth, development and nutrient element uptake of *Sansevieria trifasciata.* **Methods/Statistical analysis**: In the study, *Sansevieria trifasciata* plants were exposed to 3 different frequency values as 600 HZ sound wave in the first week, 1240 HZ in the second week and 1600 Hz sound waves in the third week at 90 dB adjusted as constantly. At the end of applications practiced each week, nutritional element and chlorophyll analysis were performed in leaf samples. **Findings**: The content of nitrogen, potassium, and phosphor increased in the plants at 90 dB that was kept as constant during the research process and 600 HZ that is the first frequency value when they underwent a stress. When the frequency level was increased to 1240 HZ, whereas phosphor and potassium uptakes decreased significantly than the control plants, the level of nitrogen was determined as nearly the same with the control plants. In terms of calcium, magnesium, and zinc element contents, zinc and magnesium at 600 HZ value was at a lower value than the control plants and calcium had a closer value to the control plants. Finally, there was no change at chlorophyll content in plants kept at the lowest frequency. However, as the frequency increased, in other words as the stress increased, the increase at the amount of the chlorophyll also appeared significantly. **Application/Improvements:** The results indicated that N, P and K uptake increased at 1600 Hz; and Mg, Ca and Zn uptake increased at 1240 HZ. Fe uptake was negatively affected at all frequency levels. The chlorophyll content found no significant at any frequency value.

Keywords: DB, Improve, Nutrient Content, Ornamentals, Stress, Sound

1. Introduction

The environmental factors have a great effect upon the physiologic and biochemical processes that provide the plants to grow, survive, grow old, reproduce, and spread. The stress leads to metabolic and physiologic changes in plants that affect growth and development directly[1].

Different sound intensities included among the abiotic stress factors have effects upon the growth and development of plants as an alternative mechanic stress[2,3]. Indoor plants taking place within the houses and workplaces are within the plant groups that are exposed to constant sound stress. [4]Indicated that since their carbon dioxide release at night, ornamental crops might have significant importance to human health. Snake plant (*Sansevieria trifasciata*), homeland of which is the tropical area of West Africa is resistant against drought and lack of water. It is more efficient to provide oxygen to indoor areas than the other plants; it cleans the air and evolves oxygen at nights. Due to its absorbing harmful gases spreading out of the stationary equipment in offices with ventilation problem, it is beneficial to keep at a great number.

Plant nutritional elements are highly important for the growth and development of plants. Micro and macro nutritional elements absolutely necessary for vital events as well as cell growth and reproduction in plants are taken out of the area they exist by the roots[5].Stress factors also affect the plant nutrition.

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In this study, the changes at nutritional element uptake of snake plant (*S. trifasciata*) plants in sound fields created by sound waves at a constant sound intensity level (dB) and 3 different HZ values were researched. The aim to choose an interior type as the sample plant is these plants' maintaining their lives at a constant sound stress in fields such as houses and workplaces. Because the sound frequencies are not constant in houses and workplaces, the frequencies were changed in the experiment and response of plants' nutritional element uptake was analyzed.

2. Material and Method

2.1 Sound Sizes

The sound pressure $p(\mathrm{t})$ changes according to the time and is a size that cannot be characterized with sinusoidal vibrations. The second most important size of the sound is sound velocity (v (t)).This size also changes according to time. The rate of sound pressure to sound velocity gives a sectional and time-dependent constant on a plane wave. This constant is a characteristic size of the environment and is referred as internal impedance or internal resistance:

$$Z_0 = \frac{\rho}{v}$$

Here; ρ is the intensity of the environment and v:sound velocity and c: sound propagation velocity.

Perception limits of people include several different sound intensities. And this brings us to use the unit of decibel [dB] which is a measurement of level. The level mentioned here is defined as Sound Intensity and sound intensity is the amount of sound energy flowing out of a unit area[6].

$$\mathrm{I} = \frac{W(watt)}{A(m^2)}$$

In this definition, W is the amount of energy propagating out of the sound source and A is the area the sound energy flows through.

The level of sound is perceived logarithmically. The sound intensity level is also mentioned logarithmically in general. This level is defined as the logarithm of the rate of an energy-physical size to a specific basic value. In order to create this rate, the amount of the lowest sound we can hear is taken as reference. This amount of energy is 1picowatt/m^2; namely, 10^{-12}W/m^2.Another meaning of dB is the perceived unit level of sound or level of noise.

For sound intensity level, the basic sound intensity value is the acoustic nerve at I_0; 1000 Hz:

$$L_I = 10.\mathrm{Log}\frac{I}{I_0}\left[dB\right]$$

The sound intensity is proportional with the square of the sound pressure *($I \sim p^2$)*. Here, the level of sound pressure is found with the formula:

$$L_p = 10.\log\frac{p^2}{p_0^2} = 20.\log\frac{p}{p_0}\left[dB\right]$$

Here, basic sound pressure is accepted as p_0; and, the sound pressure at acoustic nerve at 1000 Hz is accepted as 2.10^{-5} Pa.

Sound level meters directly show the level of sound pressure in decibel unit through the help of these formula[5]. The distance between the two crests is called as the wave length and the number of wave crest observed within a second is called frequency. As a physical term, this has the same meaning with the quantity called as the level of sound by the musicians. Low frequencies are bass sounds and high frequencies are high-pitched sounds.

3. Experimental Details

In the experiment, dB indicative sectional adjustable Amplifier, signal Generator (Adjustable frequency oscillator) in order to create a frequency, sound-deadening 3 2x2 rooms open able and closable on 4 sides and a sound level meter were used. The thickness of glass used in the experiment rooms are 4mm and this is double glazing form. The gap between the these glasses is 10.5mm.

Totally 3 rooms were used in the conducted experiment. Each room only heard the sound inside itself and no outside sound came into any rooms. The rooms in the experimental area should not hear each other. So, each room was tested before conducting the experiment. The speakers used in each room had the property of 360^0 sonority. These speakers were placed in the center of the room at a 43 cm height from the ground (Figure 1).

The type of sound that were sent is test signal at a sin wave form. This type of sounds can be called basic sounds. For a simple example a tuning fork sound. The duration of this sound is continous i.e., sound signal is uninterrupted during the duration.

In the experiment, 2-liter pots including the plants were placed to the cabins to which sound waves having different frequency values were applied. In the

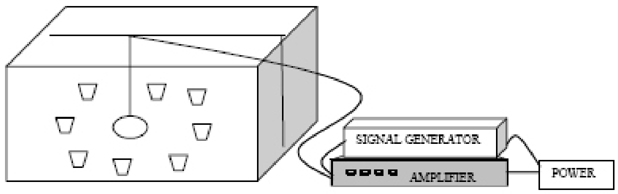

Figure 1. Experimental setup.

experiment, with three replications, 15 pots of the same type were placed within each cabin because the samples will be taken for 3 weeks. These pots were placed circularly in each room. Each pot was placed 65 cm away from the speaker, so whole pots used in the experiment were in the same distance to the speaker. The reason for choosing the distance as 65 cm is to perform sound measurements in a sufficient distance from the source in order to protect the sound pressure and sound velocity rate and this is nearly 1 m. Then, dB value measured with sound level meter was taken to 90 dB, and this dB value was adjusted constantly from the amplifier. The experts mention that being exposed to the sound over 85 dB can be dangerous. So, dB value in the experiment was chosen as 90 dB constantly. Moreover, control plants were placed to a cabin in which no sound waves were sent, and the applications were compared with the control.

The application period of the experiment lasted for 3 weeks. To the each cabin, different sound fields were created through the sound waves at 90 dB sound intensity with 600 Hz for the 1st week, 1240 Hz for the 2nd week and 1600 Hz for the 3rd week were sent, respectively. During the experiment, whereas the dB value was kept at constant, applied amount of frequency was changed at the end of each 7 days. Namely, at the end of a plant analyzed at the end of the 3rd week stayed under the effect of the sound field created at 3 different frequency levels. The sound wave was sent to cabins for 30 minutes in 6 hour intervals for twice. These hours were between 9.00 and 9.30 in the Morning and between 3.00-3.30 in the Afternoon. In the experiment, the plants were only within a closed area when they were exposed to stress. The plants were not fed during the 3-week experimentation period and they were only watered at equal amounts once in 2 days. The leaf samples were taken in the 7th, 14th, and 21st days after starting the sound application. In nutritional element analysis, total nitrogen was determined according to Kjeldahl and phosphor was determined according to Barton methods. Dry combustion method was used for K, Ca, Mg, Fe, and Zn analysis. The samples were dried and grinded, and then combusted at 550 ^{0}C, solubilized within %3.3 (v/v) HCl and their element concentrations were read at atomic absorption spectrometer (Varian 220 FS) in emission mode. The amount of chlorophyll was determined colorimetrically based upon leaves' homogenize in 80% acetone[7].

4. Results and Discussion

When the plant nutritional element contents in the leaves were analyzed sound application at different frequencies did not create a statistically significant difference for the snake plant (S. *trifasciata*) plant's nutritional element uptake of other elements except from nitrogen and phosphor (Table 1).

The content of nitrogen, potassium, and phosphor increased in the plants at 90 dB that was kept as constant during the research process and 600 HZ that is the first frequency value when they underwent a stress. When the frequency level was increased to 1240 HZ, whereas phosphor and potassium uptakes decreased significantly than the control plants, the level of nitrogen was determined as nearly the same with the control plants. While the level of frequency was 1600 HZ, it was determined that nitrogen, phosphor and potassium contents in plant leaves were higher than the control plants; in other words, uptake of these three elements increased (Figure 2 and Figure 3).

When calcium, magnesium, and zinc element contents were analyzed, zinc and magnesium at 600 HZ value was at a lower value than the control plants and calcium had a closer value to the control plants. When the plant underwent the first stress with 600 HZ, uptake of these three elements decreased. When the level of frequency

Table 1. Plant nutritional element content in leaves of snake plant (*Sansevieria trifasciata*) plant exposed to different sound frequencies

Nutritional element	Control	600 HZ	1240 HZ	1600 HZ	LSD % 5
N	15.06	18.2	15	17.8	
P	2154	2522	1699	3007	
K	1726 b	3180 a	882 c	2693 a	785.76**
Mg	836.13 a	640.9 b	893.3 a	796 a	114.95**
Ca	3737 ab	3118 b	4391 a	3444 b	732.20*
Fe	35.3 a	26 bc	29.1 b	22.5 c	5.62**
Zn	2.352 b	0.788 b	4.625 a	2.266 b	1.85*
Chlorophyll	<0.005	<0.005	0.148	1.62	

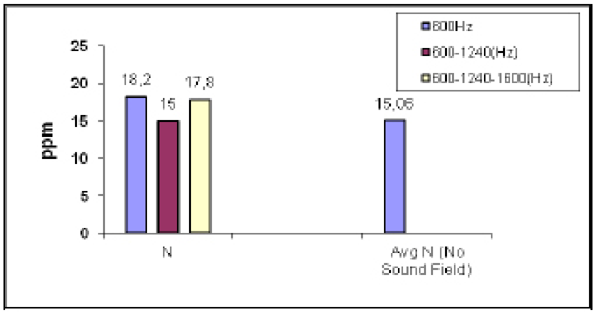

Figure 2. Nitrogen contents at different frequencies.

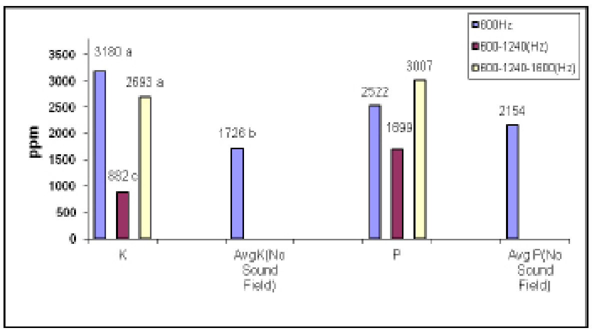

Figure 3. Phosphor and potassium contents at different frequencies.

increased to 1240 HZ; calcium, magnesium and zinc contents were determined at the highest level and content levels in leaves of calcium and zinc elements at 1600 HZ had values closer to the control (Figure 4 and Figure 5) .The content of iron had a value at a lower level than the control plants in whole applications as being different from the other elements (Figure 6).

When the amount of chlorophyll was analyzed, no change at chlorophyll amount was determined in plants kept at the lowest frequency. However, as the frequency increased, in other words as the stress increased, the increase at the amount of the chlorophyll also appeared significantly.

In [8]revealed that only the biological factors were not sufficient upon the plant growth; although the cell growth is always controlled by the chemical environmental factors, mechanical factors, also, have effects upon the cell structure and growth. In recent years, the stress applied low can create an advantage on growth and development inducing the cells. In this sense, the stress has no harmful effects, and it can even be mentioned as having a positive effect. Apart from the nitrogen and phosphor, different sound frequencies had statistical significance upon the nutritional element uptake.

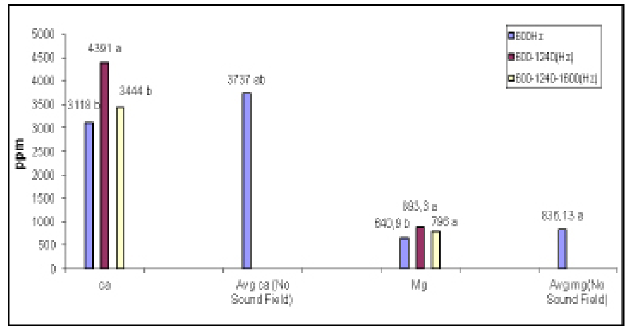

Figure 4. Calcium and magnesium contents at different frequencies.

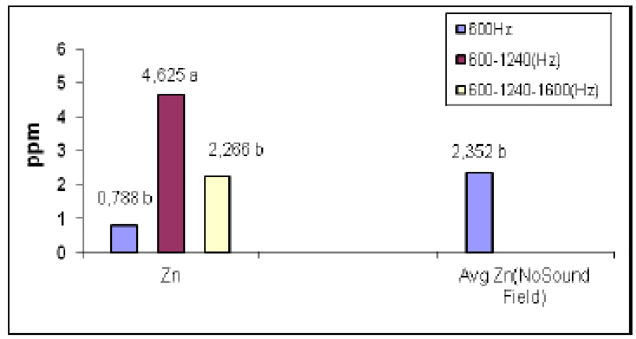

Figure 5. Zinc contents at different frequencies.

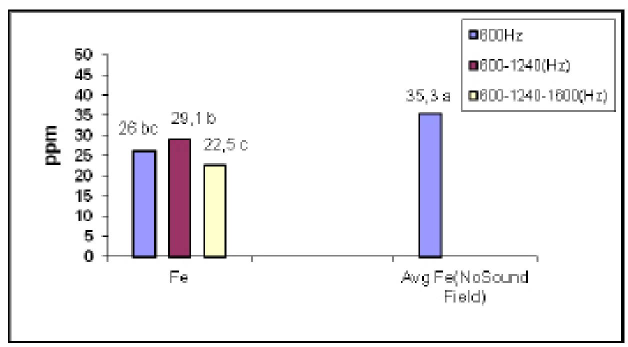

Figure 6. Iron contents at different frequencies.

The effect of frequencies upon nitrogen, phosphor and potassium was nearly the same. The nutritional uptake increased at 600 HZ frequency value and decreased at 1240 HZ value. 600 HZ was the frequency which had positive effect upon the nutritional element uptake of three important macro elements for the plants and 1240 HZ was the frequency in which damages started and negative effects were noticed. However, we also noticed re-increasing of the element contents in leaves at 1600 HZ. The reason for this is plant's preventing the growth and other metabolic events in which the elements will be used at high sound frequency. The content of the elements which will not be used and accumulated in such a case will be high. In terms of Mg and Ca content, the plants were negatively affected from the 600 HZ sound application in the first week; however, they reached to the maximum value at 1240 HZ application. In terms of Mg and Ca uptake, 1240 HZ was the most efficient frequency value in snake plant (*S. trifasciata*)plants. Iron uptake was negatively affected from the stress created by the sound waves in whole frequencies. Zn uptake was negatively affected from 600 HZ frequency level in the first week as in Mg and Ca. Zn content higher from 1240 HZ was determined.

In [9]determined that sound waves expedited the growth of callus in chrysanthemum. In our study, it was determined that nutritional uptake in specific frequency values changed according to the elements, but increased through the sound application. In their study carried out with paddy, [10]specified that body length, fresh weight, number of roots and total length of the root increased under the sound wave at 106 dB sound level, 200 and 400 HZ frequency values. They also determined that the data changed in reverse when the frequency reached to 1 KHZ. In this study, it was determined as similar to the study of Bochu et al. that sound created a positive effect upon the nutritional element uptake while the level of frequency was low; however, as the frequency increased (at 1600 HZ frequency value) it created a negative effect upon the uptake of whole element except from the content of chlorophyll.

According to these results, in terms of snake plant (*S. trifasciata*) plants, the plants decreased their nutritional element amounts except from nitrogen and potassium when they were exposed to stress through the sound waves at 600 HZ, the first frequency value. When the level of stress increased at 1240 HZ frequency value, the content of phosphor and potassium from the macro elements decreased and the amount of other elements increased. While the level of frequency was the highest, in other words when the stress factor was at a maximum level, uptake of whole nutritional elements was found as higher than the control plants. This means that along with the increase at constant level of sound 90 dB and frequency value, the plants increased their nutritional element uptake when they were exposed to the stress. The plants were more benefited from the nutritional element contents existing in the soil. The reason for finding the iron content at a lower level than the control plants in each level of sound can be arisen from the interaction with the uptake of other elements. The iron shows an antagonistic effect with zinc and calcium (interplant's incompatibility). When the uptake of other cations from the soil is high, the uptake of iron with +2 value is prevented[11,12].

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