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Effect of Music on Plants – An Overview

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ABSTRACT

Plants are known to respond to stimuli and music is considered as one. It has been observed that different types of sound affect the health of plants differently. In this paper, the influence of acoustic frequencies including those of music on the growth pattern of plants as observed by many researchers have been reported. Besides, the authors have carried out a pilot study to observe the response of *Tagetes* sp. (marigold) to Light Indian Music and Meditation Music as well as to noise. They have also monitored the germination of *Cicer arietinum* (chickpea) on exposure to Light Indian Music. It could be commented that music promoted the growth and development of the plants, including germination whereas noise hindered it. Possibly, specific audible frequencies and also musical frequencies facilitate better physiological processes like absorption of nutrients, photosynthesis, protein synthesis, etc. for the plant and this is observable in terms of increased height, higher number of leaves and overall more developed and healthier plants.

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1. Introduction

Music is known to have a profound effect on human beings. Plants are also living objects that breathe and grow. Some scientists are of the opinion that plants are devoid of a nervous system and therefore are unable to understand music or respond to music. However, there are a few studies which suggest that music may have distinct effect on plants. Sir Jagdish Chandra Bose was one of the pioneers to study the behavior of plants in response to various stimuli ([1]-[3]). Music is a harmonious and coherent blend of various frequencies and vibrations and has many different forms, qualities, and pitches. It is believed that loud and unharmonious sounds can ruin the mood and health of a plant and blossoms. Soft rhythmic music on the other hand is better for their growth and blossoms, and thus may increase plants' rate of growth, their size and influence their overall health. The work of Reddy *et al.*, showed that Indian classical ragas had a positive impact on overall plant protein production on plants like wheat, spinach, horse gram, soya and paddy. Musical vibrations stimulated seed germination of 'okra' and zucchini ([4]-[5]).

Music not only accelerates growth but also significantly influences the concentration of various metabolites; e.g. chlorophyll and starch are increased by it [6]. Experiments by Chivukula and Ramaswamy [7] showed that soothing vibration in the form of vedic chants and Indian classical music endorsed growth of rose (*Rosa chinensis*) whereas rock music stunted growth. Plants exposed to western music were found largely similar to the control plants except for the fact that the density of thorns in these rose plants were higher. Indole Acetic Acid (IAA) is an essential plant hormone that helps in plant's growth and development. Zhu and co-workers observed that IAA content in plants were found at an increased level in six species of vegetable plants when exposed to musical acoustic frequencies in comparison to the control plants [8]. Yi and colleagues reported that sound stimulation increased the metabolism of roots and hence the growth of chrysanthemum [9]. Vanol and Vaidya applied sounds of varying frequencies and types (classical music, rhythmic rock music and non-rhythmic traffic noise)

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to Guar plants and monitored the parameters such as number of seeds germinated in petri-dishes, difference in height of plants and number of leaves for 13 days, on daily basis. Their results showed positive effect on exposure to classical music and rhythmic rock music, and negative effect of non-rhythmic traffic noise as compared to control or untreated plants. On the contrary some other researchers showed that compared to silence, any kind of sound promoted growth in bean plants ([10]-[11]). Sonic exposure increased the oxygen content and level of polyamines in cucumber and Chinese cabbage, thus improving overall plant health [12]. Findings also suggested that high frequency sound waves retard the growth of *Aspergillus* spp., a type of fungus [13]. This fact can be tapped for the benefit of the food industry.

2. Sound, Music and Standing Waves

In a musical scale, every note has its own frequency value [14]. Ratio of the frequencies of two notes determines the musical interval which describes the difference between two notes. Music that is pleasant to the ears is usually a combination of simple frequency ratios. Musical notes in a given scale played sequentially generates melody [15]. When sound waves propagate through air, it leads to air pressure disturbance. Thus, vibrations from tuning fork, musical instruments, diaphragm of a loudspeaker, vocal cords, etc. create air pressure disturbances of the corresponding frequency and intensity. Basically, two conditions that are required for the generation and propagation of sound waves are a vibratory disturbance of frequencies in the audible frequency range of 20 Hz to 20,000 Hz and an elastic medium. Speed, pitch, loudness, quality or timbre characterizes sound waves [16].

Music is created in different instruments by forming standing waves. Whenever two waves with equal frequency and wavelength moving through a medium perfectly reinforce each other, standing waves result. Standing waves can occur in all elastic media and are created in the guitar strings, skin of the drumhead, column of air in flute, etc. Whenever, a note is played in a musical instrument, a medium vibrates due to which the sound is produced. Frequency of the desired note is the fundamental frequency caused by the first mode of vibration. Interestingly, many higher modes of vibration always naturally occur at the same time when a specific note is played. Fundamental frequency and all its overtones together produce the sound of the desired musical note. Overtones are the integral multiples of the fundamental frequency and all have different intensities - lower than that of the fundamental frequency. Fundamental and the overtones are also referred as harmonics. The frequencies of harmonics form an arithmetic sequence. Fundamentally, certain frequencies are associated with different musical notes. For example, frequency of the middle C on the piano keyboard has a frequency of approximately 262 Hz ([14], [16] – [20]).

3. Growth in Living Organisms

An irreversible permanent increase in size, volume or mass of a cell or entire organism is termed as growth. All living organisms including plants experience growth. At a cellular level, growth is generally regarded as a consequence of increase in the amount of protoplasm measuring which directly is difficult. So, growth is measured in terms of parameters like increase in weight, length, area, volume, cell number, etc. Increase in growth per unit time defines growth rate. Per unit time growth can also be expressed in terms of initial parameters, thus, accounting for relative growth measurement. Cell division leads to growth of plant; and nucleus, chloroplast, vacuoles and ribosomes play an important role in this process. [21]

4. Growth Influenced by Acoustic Frequencies

Sound is a wave and music is a specific kind of melodious sound. These waves capable of moving through elastic media are characterized by specific frequencies. Plants being living organisms get affected by external stimuli. Many researchers have used sound wave frequencies as external stimuli and studied their effect on plants. Collins and Foreman [22] subjected beans and impatiens plants to sounds of different frequencies (5000 Hz, 6000 Hz, 12000 Hz, and 14000 Hz). Under similar environmental conditions favourable for plant growth, the plants were kept inside a chamber and the sound waves were directed towards them. The process of speaker diaphragm moving back and forth generated a wave in the vicinity in air medium. Compression portion of the wave generated increased pressure and rarefaction generated reduced pressure and this propagated along the surface of the leaves creating a scrubbing or brushing action on the leaf surface. This helped in removal of the moisture film and facilitated the leaf to breathe or transpire better. Most favorable growth was observed in both beans and the impatiens plants when the wavelength of the sound played matched with the dimension of the leaf of the plant [22]. Xiujuan and team reported that sound wave accelerated the synthesis of RNA and soluble protein that increased the level of transcription and in turn promoted better growth [23].

Metabolism in plants can be greatly affected by music. Plants are reported to behave differently to different music types and frequency. Sternheimer, a French physicist and musician, has framed melodies that apparently help plants grow. The notes are designed on the basis of the quantum vibrations that occur at the molecular level as a protein is being assembled from its constituent amino acids. Length of a note correspond to the real time that is taken by each amino acid to come after the next. Thus, on playing the appropriate tune, production of protein increases in the plant and hence, its growth is stimulated. Sternheimer remarked that tomatoes exposed to such tunes grew two and a half times better than the control ones; even virus growth in tomato plants could be stopped by playing tunes that inhibited enzymes essential for it ([24] – [25]).

Growth rate in terms of height and biomass respectively increased by 20% and 72% when treated with classical music, i.e. raga music played on Indian musical instruments like flute, violin, and harmonium. Similar positive effect was observed in field crops - like size increment in the range of 25% to 60% above other regional crops. Petunias and marigolds were found to flower two weeks before the scheduled time when exposed to the rhythm of bharatnatyam, an ancient Indian classical dance style [26].

Cai *et al.*, exposed mung bean (*Vigna radiate*) to sound of frequencies 1000–1500 Hz, 1500–2000 Hz, and 2000–2500 Hz, and measured their development in terms of mean germination time, length and weight of the stem and root that developed from the bean. They reported significant reduction of germination time and increase in growth of the seedlings when exposed to frequency of 2000 Hz and intensity of 90 dB [27].

Frequency of audible sound may stimulate the opening of leaf stomata and thus, facilitate the plant to absorb more dew, more light energy and help it to grow better. Audible sound with certain frequencies are expected to enable better respiration and absorption of nutrients as well. Vibrations are caused in plant leaves due to sound waves. Sound energy also gets reflected and diffracted around the leaves and may thus affect the insects near the plants. Not only this, some researchers even report that plants also emit acoustic waves. Plant Acoustic Frequency Technology (PAFT) uses an acoustic frequency generator to produce appropriate acoustic wave that is similar to the frequency of the specific sound of the plant itself. It has been reported that if the applied frequency resonates with the plant's natural frequency, then rate of photosynthesis and cell division increases leading to faster growth of plant and hence fruit bearing time for the plants under resonant frequency treatment is reached before the control plants. Experiments performed with sweet potato, cucumber and tomato indicated the improvement of crop quality and enhanced disease resistance capacity. The yields of sweet potato, cucumber and tomato exposed to the specific frequencies were 63.05%, 67.1% and 13.2% higher than those of the control group, respectively ([28] – [30]).

Hou *et al*., measured the emissions from the phylodendron leaves and found that they produced a frequency of 50 Hz to 120 Hz. They also observed that these leaves accepted external stimulus of frequency lower than 150 Hz and showed a good response in terms of better growth. [31].

Chemical fertilizers and pesticides are hazardous for plants and in turn for the human population who consumes their product. Various studies have shown the positive effect of sound waves including music on various plant parts which ultimately led to a better and healthy yield of plants. Based on the exposure time, sound pressure levels and frequencies plants, in general, showed a positive growth trend and better immune system. Low frequency sound is known to activate enzymes, increase cell fluidity and enhance other growth parameters like DNA replication and cell cycling. The living matter - protoplasm in plants is in a constant state of motion and with exposure to music this motion is accelerated leading to higher growth and more production ([32] – [33]).

Dorothy Retallack [34] conducted several experiments to observe the effect of music of different types on plants and inferred music as a positive factor for growth. Classical music of specific frequency, interval and rhythm accompanied with dynamically changing lyrics positively influenced root growth and mitotic division in onion plants. Mi-Jeong and co-workers played 14 different classical music pieces including Beethoven's music to rice plants and monitored gene expression. Audible sound at frequencies 125Hz and 250Hz made genes more active for the process of DNA code translation into biological processes like growth ([35] – [38]).

5. Pilot Investigation

In this pilot investigation, the authors aimed to investigate any known effects of Light Indian Music and Meditation Music on the growth and health of marigold (*Tagetes*) plants. Vis-à-vis the effect of noise on marigold plants has been investigated. Germination of chickpea (*Cicer arietinum*) on exposure to music has also been studied.

5.1 Materials and Methods

Marigold belongs to the genus *Tagetes* and specifically, it can be *T. erecta*, *T. patula* and *T. tenuifolia*, where T stands for *Tagetes* [39]. This investigation was divided into three sub-groups. Each sub-group chose a specific type of acoustic frequency. They were 'Meditation Music', 'Light Indian Music' and 'Noise'.

For every sub-group, two plants, approximately less than one feet in height were taken in two different pots and all the basic conditions required for plant growth, like air, water, light, fertilizer, etc. were kept similar. One pot was chosen as 'Treatment plant' (marked T) and the other as 'Control plant' (marked C). Every day, the selected type of sound was repeatedly played for four hours to the plant marked 'T' and during this period, the other plant marked 'C' was not exposed to any specific audio wave. This method was continued for one complete month on each of the three sets of plants. The growth pattern of every plant was monitored regularly, once every week, according to certain parameters like height attained, number of buds and flowers that appeared along with the general growth. Growth of leaves was also assessed in terms of their numbers and size.

Separately, another experiment was carried out to observe germination of chickpea (*Cicer arietinum*) seeds in presence of 'Light Indian Music' vis-à-vis no music. Thirty seeds were sown in each pot. The number of seeds that germinated was recorded; their general health and development into saplings were also observed. The preliminary facts that emerged from these experiments are summarized below.

5.2 Result and Discussion

With Light Indian music, it was observed that the rate in gain of height attained by the treated marigold plant (T) was better than the one not treated. Number of buds and number of flowers were always higher on the treated plant. A particular leaf marked on each plant to monitor the growth also showed a higher gain in its length and hence in its area with exposure to music. In Fig. 1 below, the photographs of the 'Control plant (C)' and 'Treatment plant (T)' for Light Indian Music are shown.

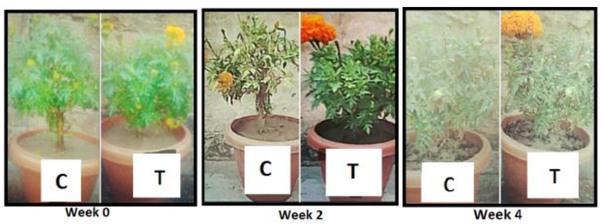

Fig. 1 Various Stages of the Marigold Plant Set exposed to Light Indian Music

Similarly on exposure to meditation music, the different factors that are selected as attributes of growth, i.e. height attained, number of buds and flowers, including the leaf length are always higher in the treatment marigold plant. So, it is observed that in general, the growth observed in the plant listening to music (T) is faster and better than the one not listening to the music (C). Fig. 2 displays the pictures of the 'Control plant (C)' and 'Treatment plant (T)' for Meditation Music.

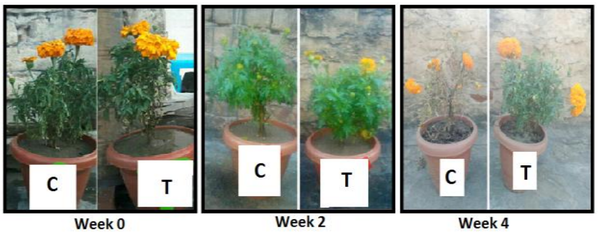

Fig. 2 Various Stages of the Marigold Plant Set exposed to Meditation Music

Under the exposure to noise, both treatment and control marigold plants showed similar growth patterns in the beginning, but second week onwards number of buds slightly decreased in the treated (T) plant. In the third and fourth weeks, there was a considerable reduction in the growth rate of the plant exposed to noise in terms of lesser number of buds, flowers and growth of leaf. The plant treated with noise finally started drying during the fourth week as is apparent from the snapshots of the plant exposed to noise (T) and the respective control plant shown in Fig. 3. The plant exposed to noise tried to bend away from the direction the noise was coming from and was greener towards the farther side from the noise suggesting the plant's aversion to noise.

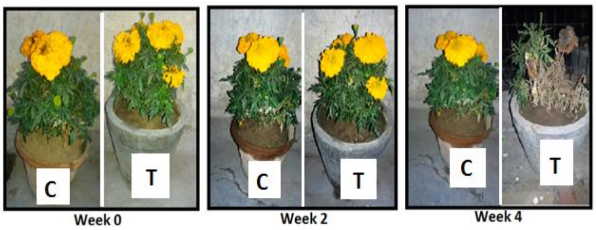

Fig. 3 Various Stages of the Marigold Plant Set exposed to Noise

In the germination experiment, sprouts were slightly visible on the second day after the chickpea seeds were sown - 3 in the treated pot and 2 in the control pot. On the fourth day, 16 saplings were there in the treated pot and 7 in the other one. On the sixth day, the number of saplings rose to 23 in the music treated pot and it was 12 in the control pot. Throughout the duration of germination and development of the saplings, the ones exposed to Indian Light Music were blooming better compared to the control saplings. It was noted that the height of the tallest plant was 14 cm in the control pot whereas it was 13 cm in the music treated pot. Since, the number of saplings in the treated pot was more, the average nutrition available per plant was slightly less compared to the control plant and that possibly was reflected as an increment of 1 cm in the tallest control sapling compared to the treated sapling. Chickpea is a winter season crop. As the experiment was performed during the month of August (rainy season), hence the saplings started to dry off gradually around the 21st day – slower in the music treated pot (the number of saplings was 22 in the treated pot, and 9 in the control pot on 21st day) (Fig. 4).

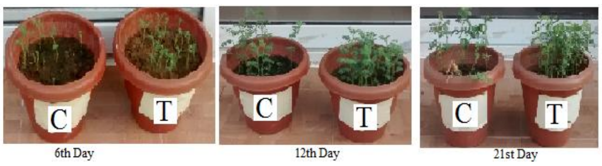

Fig. 4 Various Stages of the Germination and Development of Seed Set exposed to Light Indian Music

The experiments designed here show that soft rhythmic audible frequencies (that is music) expedites germination of seeds, growth and development of plants. Possibly, music leads to faster absorption of nutrients from soil and better production of metabolites which in due course sums up to growth at a better rate. Increased height of the plants, higher number of leaves and overall more developed and healthier plants resulted when exposed to musical frequencies.

6. Conclusion

Summing up all the experimental observations of various workers, it can be stated that specific audio frequencies in the form of music facilitated the germination and growth of plants, irrespective of the music genre. The pilot study of the authors is in line with the similar observations noted by several other researchers in this domain ([4] – [6], [8] – [10], [25] – [26], [30], [34] – [35]) as has been discussed. On the other hand noise which is a non-rhythmic and unharmonious superposition of various audio frequencies was observed to have a negative effect on the growth of plants. This observation is similar to the observations of Chivukula and Ramaswamy [7] for rock music which is also not a soothing vibration.

The increased rate of growth in terms of more flowers, leaves, buds etc. suggests that specific audible frequencies including music can benefit the agricultural sector by increasing the productivity. Simultaneously, this might reduce the requirement of toxic chemical fertilizers and pesticides and thus, reduce environmental pollution and facilitate the well-being of plants, animals and human beings. There is a wide scope to carry out further research in this interdisciplinary domain wherein physicists, biologists and agricultural engineers can get actively involved to devise a scheme to nurture this green way of agriculture.

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