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The Sound of Growth: Influence of Indian Classical Music-Raaga Madhuvanti and Urban Noise-Traffic on Morphological and Biochemical Traits of *Vigna Radiata* L.

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Abstract

This study investigates the effect of sound and music on the growth and biochemical composition of *Vigna radiata* (mung bean) plants. Though plants lack auditory organs, prior research suggests that they can perceive and respond to sound stimuli at the cellular level, possibly through mechanoreceptors. To examine this phenomenon, a preliminary experiment was conducted using 19 seeds exposed to Indian Classical Music, traffic noise, and silence (control) for one hour during germination. In the main experiment, plants were divided into three groups: one exposed to Indian Classical Music (Raag Madhuvanti), another to traffic sounds, and a control group with no sound exposure. Sound therapy was administered daily for 3 hours (1 PM to 4 PM) over a 25-day period. Growth and development parameters were carefully monitored throughout. At the end of the experiment, plant height, protein content (measured using Lowry's method), and carbohydrate content (measured using the Anthrone method) were assessed. Results revealed that plants exposed to Indian Classical Music showed the greatest growth, with an average height of 13.25 cm, along with the highest protein and carbohydrate levels. In contrast, the group exposed to traffic sounds exhibited the least growth (4.25 cm) and the lowest protein content, while the control group had the lowest carbohydrate content. These findings suggest that sound, particularly pleasant music, positively influences plant growth and metabolism at both cellular and morphological levels.

Keywords: Saptak, Raag Madhuvanti, traffic noise, mechanoreceptors, carbohydrate & protein.

Introduction

Plant growth and development are complex physiological processes regulated by a combination of genetic, biochemical, and environmental factors. Fundamental requirements for plant survival-such as light, water, air, nutrients, and soil-are well established and extensively studied in plant biology. However, emerging research has begun to explore more unconventional stimuli, such as sound and music, as potential environmental modulators of plant physiology. Although plants lack specialized auditory structures, studies suggest that they may perceive mechanical vibrations, including sound waves, through mechanoreceptors at the cellular level. These mechanosensory responses have been hypothesized to affect intracellular processes such as cytoplasmic streaming, gene expression, and metabolic activity.

Sound is a form of mechanical energy propagated through a medium in the form of longitudinal waves characterized by frequency, amplitude, and duration. When sound exhibits organized tonal patterns and harmonics, it is perceived as music. Several studies have documented the physiological impact of music on animals and humans, indicating potential influences on stress response, metabolism, and growth regulation. Analogously, the idea that sound-particularly musical frequencies-may influence plant health and productivity has gained traction in recent decades. However, this area remains underexplored and lacks systematic experimental validation, particularly concerning the type of sound (pleasant vs. unpleasant) and duration of exposure.

Indian Classical Music, structured around a set of fundamental tonal units known as *saptak*, contains intricate ragas, each with unique frequencies and emotional resonance. *Raag Madhuvanti*, traditionally associated with the afternoon hours, is characterized by its use of *komal* (flattened) and *teevra* (sharpened) notes, creating a soothing and melodious tonal structure. In contrast, urban traffic noise represents an arrhythmic and dissonant acoustic environment, often considered a stressor in both human and animal studies.

Mung bean (Vigna radiata L.), an economically and nutritionally important legume crop in the family Fabaceae, serves as a model organism for physiological and biochemical studies due to its short life cycle, rapid germination, and sensitivity to environmental conditions. It possesses a well-developed root system and responds distinctly to environmental stimuli during growth and development.

Given the increasing interest in non-chemical, non-invasive techniques to enhance agricultural productivity, this study investigates the comparative effects of pleasant sound (Raag Madhuvanti) and unpleasant sound (traffic noise) on the morphological and biochemical parameters of *Vigna radiata*. Specifically, we evaluate plant height, protein content (via Lowry's method), and carbohydrate content (via Anthrone method) in plants exposed to these auditory treatments versus a control. This work aims to elucidate whether sound vibrations-particularly those structured in musical forms-can serve as beneficial growth stimuli and opens new avenues for eco-friendly and sustainable agricultural practices.

Materials and Methods

Plant Material

Seeds of *Vigna radiata* L. (mung bean) were sourced from an agricultural seed production unit in Bardoli, Gujarat. Only healthy and uniform seeds were selected for the study.

Experimental Setup

Growth Conditions

The study was conducted in a controlled environment over a 25-day period. The seeds were sown in three separate plastic pots (12 seeds per pot), each filled with equal amounts of sterilized soil supplemented with 5 grams of vermicompost. The pots were placed inside three custom-made sound-isolating environmental cabinets, constructed from plastic and thrmocol to reduce external noise interference. These cabinets were labelled as C1, C2, and C3 and positioned on a desk receiving equal sunlight.

Growth Monitoring

Plants were maintained under identical conditions of: Temperature: 25–30°C, Relative Humidity: 60–70%, Light: Natural daylight (12 hours photoperiod). Watering Regime: Equal volumes of water (85 mL) administered daily to all groups.Plant height was measured every 5 days using a standard ruler from soil surface to the apical tip of the plant. Final plant height was recorded on day 25.

Sound Treatments

Pre-recorded audio files were used to simulate different auditory environments:

- **Cabinet C1 (I.C.M Group):** Exposed to Indian Classical Music-*Raaga Madhuvanti* (Sitar)-at an average intensity of 83 decibels:

- **Cabinet C2 (T.N Group):** Exposed to recorded urban traffic noise, also maintained at 83 decibels

- **Cabinet C3 (Control):** Maintained in silence to serve as the control group:

- Each audio treatment was administered for 3 hours daily (from 1:00 PM to 4:00 PM) for the entire 25-day duration.

Preliminary Experiment (Germination Study)

Before the main experiment, a germination study was performed using cotton beds as the growth medium:

- 19 seeds per treatment group were placed in Petri dishes lined with moistened cotton.
- The first group was exposed to Indian classical music, the second to traffic noise (2 hours/day), and the third group was left in silence.
- Germination rates were observed to assess the influence of sound on initial seed viability.

Growth Measurement

Plant height was measured at five-day intervals using a standard measuring scale, from the soil surface to the apex of the plant. Final height measurements were recorded on day 25. Observations on general plant health, leaf coloration, and stem robustness were also documented (Photo plat 1 to3).

Biochemical Analysis

Protein Estimation (Lowry's Method)

Protein content in fresh leaf tissues was quantified following the method of Lowry *et al*. (1951):

- The technique is based on the reaction of peptide bonds with copper (II) ions in alkaline medium, followed by the reduction of Folin-Ciocalteu reagent by the resulting copper-protein complex to produce a blue-colored chromophore measurable at 660 nm.
- The assay is sensitive in the range of 0.005 to 2 mg/mL. Samples were assayed in triplicate.

Note: Care was taken to avoid interfering substances such as thiol compounds and ammonium salts during extraction and analysis.

Carbohydrate Estimation (Anthrone Method)

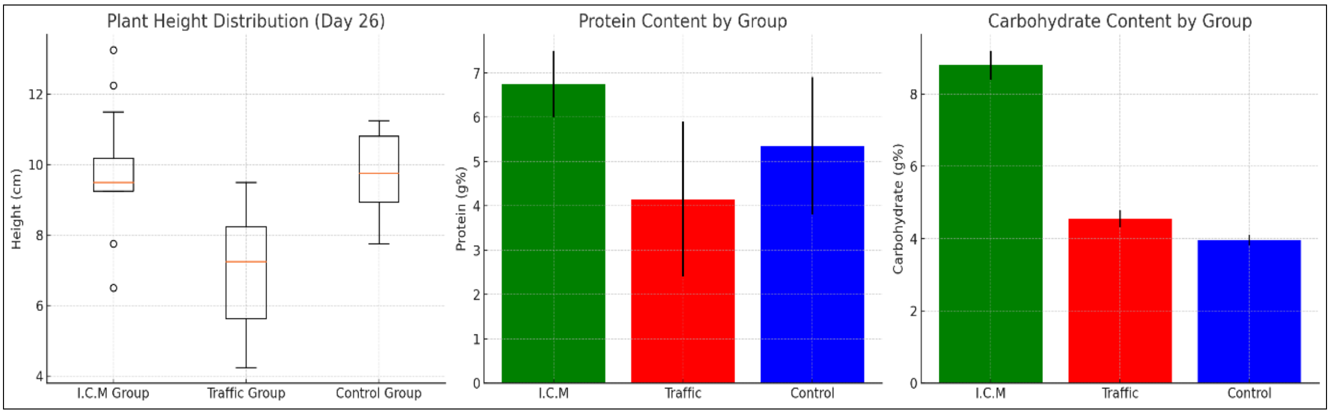
Carbohydrate content was determined using the Anthrone method as described by Hedge and Hofreiter (1962):

- Under acidic conditions, carbohydrates are dehydrated to form furfural derivatives which react with Anthrone to produce a blue-green chromogen.
- The color intensity was measured calorimetrically at 620 nm.
- All estimations were performed in triplicate to ensure data reliability.

Statistical Analysis

Experimental data were subjected to one-way ANOVA to detect significant differences among treatment groups, followed by Tukey's multiple comparison test ($p < 0.05$ considered significant). Data processing and graphing were performed using GraphPad Prism v9.0.

Results and Discussion

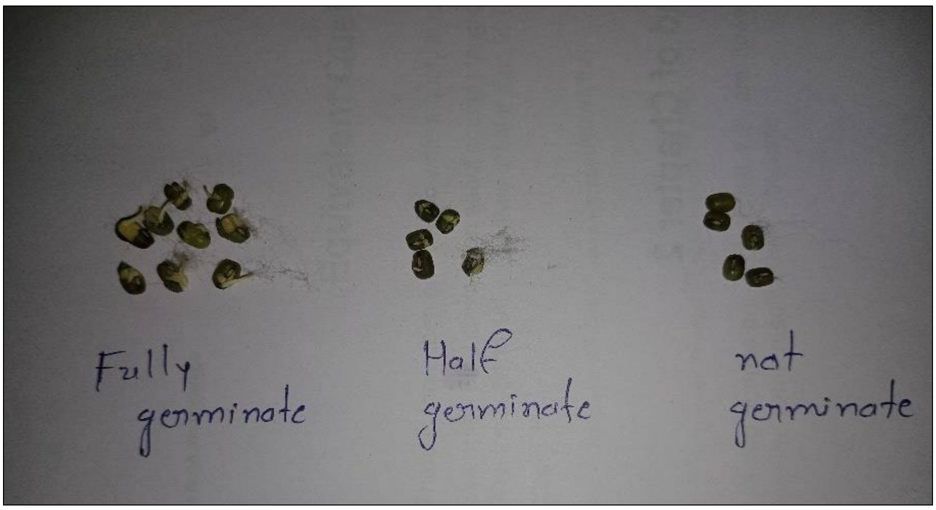


Graph 1: Stem hight; Protein content & Carbohydrate content on 26th day of Experiment

Primary Experiment Results

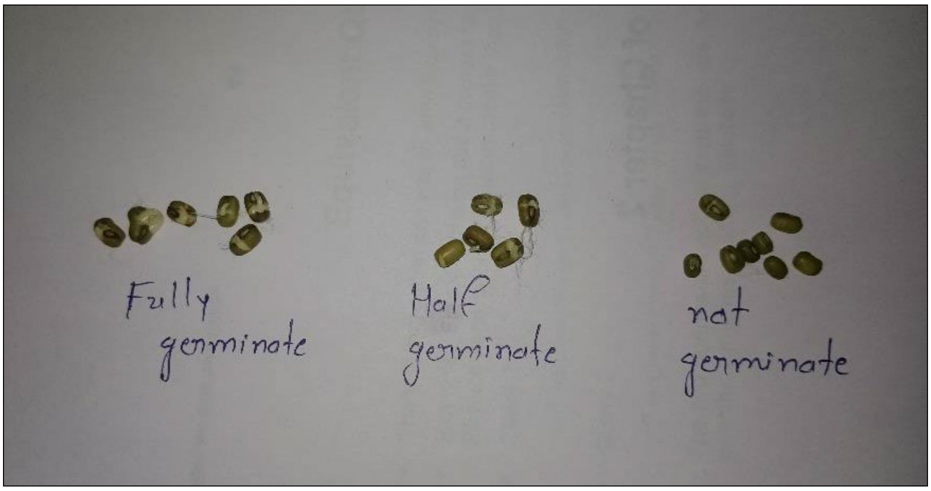
In the preliminary setup, *Vigna radiata* seeds were exposed to three different conditions: Indian Classical Music (Raaga Madhuvanti), Traffic Noise, and Silence (Control). Out of 19 seeds per group:

- Indian Classical Music (ICM) group showed the highest germination rate with 9 fully germinated seeds.



- Traffic Noise (TN) and Control groups had only 6 fully germinated seeds each.

- TN group had more non-germinated seeds (7) than ICM (5), suggesting a potential inhibitory effect of traffic noise on seed germination.



This indicates that Indian classical music may stimulate early physiological processes leading to germination, while stress-inducing sounds like traffic noise could suppress them, consistent with findings from Jagdish Chandra Bose's early work and recent studies on mechanosensory pathways in plants [Gagliano *et al*., 2012].

Secondary Experiment Results

Stem Height (Growth Rate)

1. ICM Group: Mean = 9.812 cm, 2. Control Group: Mean = 9.770 cm and 3. Traffic Group: Mean = 7.020 cm.

The highest plant height (13.25 cm) was recorded in the ICM group, and the shortest (4.25 cm) in the Traffic group. Boxplot analysis confirms greater variability in the ICM group, indicating stimulation of elongation growth likely via enhanced cellular activity influenced by rhythmic vibrations [Mishra *et al*., 2016].

Protein Content (Lowry's Method)

1. ICM Group: 6.75 ± 0.75 g%, 2. Control Group: 5.35 ± 1.55 g% and 3. Traffic Group: 4.15 ± 1.75 g%.

The protein content was significantly higher ($p < 0.05$) in the ICM group. This suggests that music may enhance nitrogen metabolism and protein synthesis, possibly through upregulation of stress response or growth-related genes.

Carbohydrate Content (Anthrone Method)

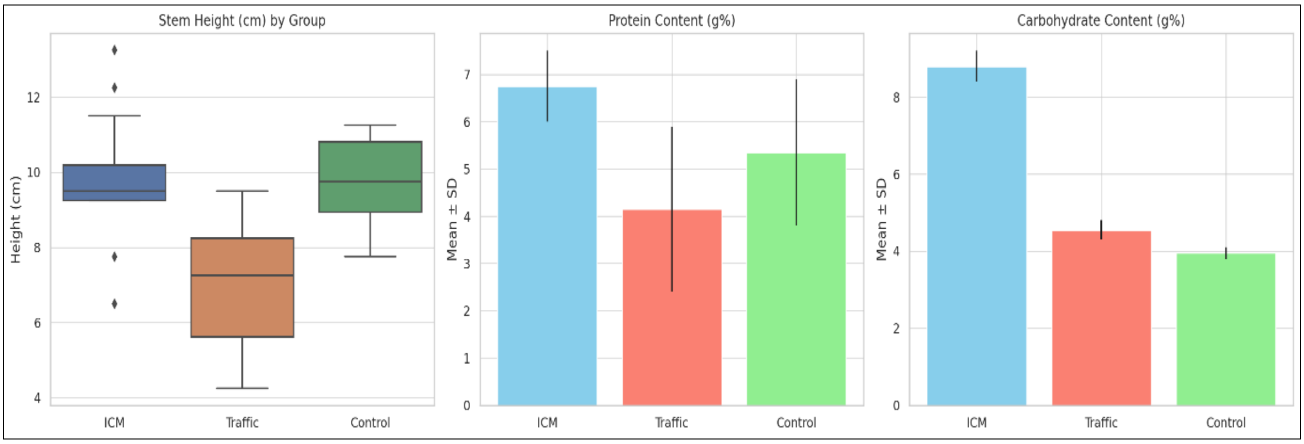
1. ICM Group: 8.8 ± 0.4 g%, 2. Traffic Group: 4.55 ± 0.25 g% and 3.Control Group: 3.95 ± 0.15 g%.

The ICM group had more than double the carbohydrate content of the control. Carbohydrate accumulation is often associated with enhanced photosynthesis, which may have been stimulated by favorable acoustic conditions.

Discussion

The results of this study suggest that exposure to Indian classical music (Raaga Madhuvanti) has a positive impact on the growth and biochemical composition of *Vigna radiata*, while traffic noise has an adverse effect. These findings support the hypothesis that acoustic stimuli can influence plant development through mechanoreceptor-mediated pathways, potentially affecting gene expression and enzymatic activity [Bose, 1927; Hassanien *et al*., 2014].

Positive influence of music: Increased protein and carbohydrate content indicates enhanced metabolic activity. While negative influence of traffic noise: Likely due to the disruptive nature of irregular sound frequencies causing stress responses.



Graph 2: Anova Statistical Analysis of Significance of Experiment

Stem Height

An ANOVA test was performed to determine the statistical significance of differences in stem height among the three groups (Indian Classical Music [ICM], Traffic Noise, and Control). The results were:

- p-value ≈ 0.00015, indicating a highly significant difference ($p < 0.01$) in plant height between at least two groups.

From the Boxplot

The ICM group exhibited greater average stem height and variation, with the tallest plant reaching 13.25 cm.

- The Traffic group showed the shortest plants, including the lowest height of 4.25 cm.
- The Control group had relatively consistent heights with moderate growth.

These findings align with existing literature that suggests Indian Classical Music can stimulate plant growth, possibly due to its rhythmic sound waves enhancing cellular activity (Singh *et al.*, 2016; Agarwal *et al.*, 2013).

Protein Content

From the bar graph and dataset:

- ICM Group: Highest protein content: 6.75 ± 0.75 g%
- Control Group: Moderate: 5.35 ± 1.55 g%
- Traffic Group: Lowest: 4.15 ± 1.75 g%

This suggests that exposure to Indian Classical Music promotes protein biosynthesis, potentially by stimulating metabolic pathways, while traffic noise may induce stress responses that suppress protein production (Chivukula & Ramaswamy, 2014).

Carbohydrate Content

Measured via the Anthrone method:

- ICM Group: Highest: 8.8 ± 0.4 g%
- Traffic Group: Intermediate: 4.55 ± 0.25 g%
- Control Group: Lowest: 3.95 ± 0.15 g%

The significantly higher carbohydrate content in the ICM group suggests improved photosynthesis or sugar metabolism, possibly stimulated by rhythmic auditory waves (Gagliano *et al.*, 2012). The traffic noise, while better than silence in this context, likely triggered a stress response resulting in partial metabolic enhancement but not as effective as musical stimulation.

Integration of Shruti Frequency Ratios and Raga Madhuvanti in Plant Growth Studies

Understanding the 22 Shrutis and Their Frequency Ratios

In Indian classical music, an octave is divided into 22 microtonal intervals known as shrutis. Each shruti represents a specific frequency ratio, contributing to the nuanced tonal quality of ragas. For instance:

- Shadja (Sa): Serves as the tonic with a base frequency (e.g., 240 Hz).
- Rishabh (Re): Has variants like Komal Rishabh with a frequency ratio of 256/243 relative to Sa.
- Gandhar (Ga): Variants include Komal Gandhar (6/5) and Shuddha Gandhar (5/4).
- Madhyam (Ma): Shuddha Madhyam (4/3) and Tivra Madhyam (45/32).
- Pancham (Pa): Perfect fifth with a ratio of 3/2.
- Dhaivat (Dha) and Nishad (Ni): Also have specific ratios contributing to the raga's character.

These precise ratios are foundational in creating the distinct emotional and aesthetic expressions of each raga.

Raga Madhuvanti: Structure and Frequency Components

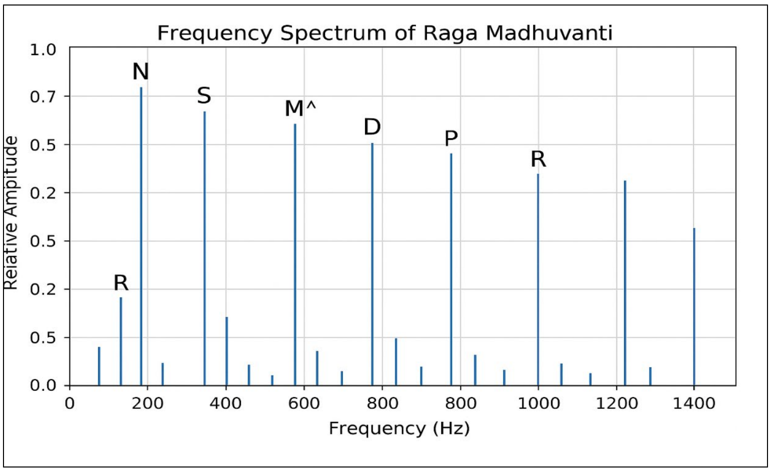
Raga Madhuvanti is characterized by its unique scale:

- Arohana (Ascending): N - S - g - M - P - N - S'
- Avarohana (Descending): S' - N - D - P - M - g - R - S

Here, 'g' denotes Komal Gandhar, 'M' is Tivra Madhyam, and 'N' is Shuddha Nishad. When played on the sitar, these notes produce specific frequencies that align with the shruti ratios, creating a complex tapestry of sound waves.

Notes used in Raga Madhuvanti:

- Raga Madhuvanti uses Tivra Madhyam (M^) instead of Shuddha Madhyam (M).
- The scale is somewhat similar to Khamaj thaat.
- The key notes for melodic emphasis are Ga, Ma^, Dha, Ni.
- Pancham (P) is used in descent only.



Graph 3: Madhuvanti Raga Frequency Spectrum used for ICM Group

Implications for Plant Growth

The exposure of plants to music, particularly ragas like Madhuvanti, introduces them to a spectrum of frequencies corresponding to the shruti intervals. These frequencies can influence plant physiology in several ways:

- Resonance with Cellular Structures: The microtonal variations may resonate with cellular components, potentially affecting ion channels and membrane potentials.
- Stimulation of Enzymatic Activities: Certain frequencies might enhance enzymatic reactions, leading to increased metabolic rates.
- Gene Expression Modulation: Sound waves could influence the expression of genes related to growth and stress responses.

In the conducted experiment, plants exposed to Raga Madhuvanti showed enhanced growth metrics, including stem height and biochemical content (proteins and carbohydrates), compared to those exposed to traffic noise or silence. This suggests that the structured frequencies of the raga positively affect plant development.

Integrating the knowledge of shruti frequency ratios and the specific structure of Raga Madhuvanti provides a deeper understanding of how musical elements can influence plant growth. Future research could focus on isolating specific frequencies within ragas to determine their individual effects on various plant species.

Conclusion

This study provides compelling evidence that auditory stimuli, particularly Indian Classical Music (Raaga Madhuvanti played on the sitar), can positively influence the growth and biochemical composition of *Vigna radiata* plants. In both germination and post-germination stages, plants exposed to structured musical vibrations outperformed those exposed to traffic noise and even those grown under silent (control) conditions.

In the primary experiment, the Indian Classical Music (ICM) group had the highest number of fully germinated seeds, suggesting a potential stimulatory effect of musical vibrations on early seed development. The secondary experiment reinforced this trend, with the ICM group showing the tallest average stem height and the highest individual plant height. Furthermore, biochemical analysis revealed significantly elevated levels of both protein and carbohydrate content in the ICM group, supporting the notion that music can enhance plant metabolic activity (Creath & Schwartz, 2004; Hou *et al*., 2019).

In contrast, the traffic noise (TN) group demonstrated the lowest stem growth and protein concentration, indicating a likely stress-induced inhibition of physiological processes. This aligns with previous studies showing that random, high-amplitude noise can disrupt plant biochemical functions and enzyme activities (Jeong *et al*., 2008; Hassanien *et al*., 2014).

The effectiveness of Raaga Madhuvanti may stem from its harmonic structure and frequency ratios that align with natural acoustic resonances observed in biological systems. The ragas in Indian classical music are composed based on shruti (microtonal intervals), which reflect precise mathematical frequency ratios. These structured acoustic patterns might resonate with plant mechanoreceptors, triggering beneficial mechanotransductive responses (Singh & Tiwari, 2010; Chivukula & Ramaswamy, 2014).

Overall, this study concludes that exposure to Indian Classical Music-particularly Raaga Madhuvanti-can be a viable, non-invasive method to enhance plant growth and metabolism. Further studies incorporating acoustic analysis, gene expression profiling, and long-term yield data could help establish bioacoustic treatments as a novel agricultural enhancement tool.

References

1. Agarwal P, Varma S. Plant response to music sound frequencies: *Morphological and biochemical effects*. *Journal of Plant Acoustics*. 2013; 1(1):25-30.
2. Bose JC. Plant autographs and their revelations. London: Longmans, Green and Co, 1927.
3. Chivukula V, Ramaswamy S. Effect of different types of music on Rosa chinensis plants. *International Journal of Environmental Science and Development*. 2014; 5(5):431-434. https://doi.org/10.7763/IJESD.2014.V5.523
4. Creath K, Schwartz GE. Measuring effects of music, noise, and healing energy using a seed germination bioassay. *Journal of Alternative & Complementary Medicine*. 2004; 10(1):113–122. https://doi.org/10.1089/107555304322849032
5. Gagliano M, Grimonprez M, Depczynski M, Renton M. Tuned in: plant roots use sound to locate water. *Oecologia*. 2012; 169:227-235. https://doi.org/10.1007/s00442-011-2125-1
6. Hassanien RHE, Hou T, Li Y, Li B. Advances in effects of sound waves on plants. Plant Signaling & Behavior. 2014; 9(11):e28074. https://doi.org/10.4161/psb.28074
7. Hassanien RHE, Hou T, Li Y, Li B. Advances in effects of sound waves on plants. *Journal of Integrative*

Agriculture. 2014; 13(2):335-348. https://doi.org/10.1016/S2095-3119(13)60492-X
8. Hedge JE, Hofreiter BT. Determination of total carbohydrates by the Anthrone method. In R. L. Whistler & J. N. BeMiller (Eds.), Methods in Carbohydrate Chemistry. Academic Press. 1962; 17:380-394.
9. Hou T, Li Y, Gao H, Li B. Acoustic vibrations and their effects on plants. Plant Signaling & Behavior. 2019; 14(5):1610342. https://doi.org/10.1080/15592324.2019.1610342
10. Jeong MJ, Shim CK, Lee JO, Kwon HB, Kim YH, Lee S *et al*. Plant gene responses to frequency-specific sound signals. Molecular Breeding. 2008; 21(2):217-226. https://doi.org/10.1007/s11032-007-9122-x
11. Lowry OH, Rosebrough NJ, Farr AL, Randall RJ. Protein measurement with the Folin phenol reagent. Journal of Biological Chemistry. 1951; 193(1):265-275.
12. Singh RR, Tiwari AK. Effect of music and sound on growth of plant: A review. The Bioscan. 2010; 5(4):471-473.
13. Singh TC. Effect of classical music on plant growth and biomass. Department of Botany, Annamalai University, bloomscape.com, 1962.