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EFFECT OF SYNCHRONIZED SOUND WAVES IN THE FORM OF INDIAN CLASSICAL *RAGAS* ON THE PHYSIOGNOMY OF *Chamaecostus cuspidatus* (Nees & Mart.) C. Specht & D. W. Stev.

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Abstract: Sound is a longitudinal, mechanical wave, simply a form of energy and moreover is a vibration (a transverse variation in pressure wave). Synchronized sound wave (music) is an ordered tonal or instrumental rhythmic sound. Putting music into the scientific definition; it is the science of sound waves embracing the characteristics such as wavelength, rhythm, intensity, frequency, amplitude and pitch. According to the present experiment, it has been observed that Indian classical *ragas* were based on sound vibration technology and science of music. The synchronized sound wave in the form of Indian classical ragas has a notable impact on the living beings including plants. It is found that Indian Classical music at different frequencies, sound pressure levels, exposure duration and distance from the source has been confirmed to encourage plant growth positively. Physiognomy is the combination of external features and growth of different parts of plant. Such growth is visible in the physiognomic characters such as plant height, north-south spread of the branches, and east-west spread, number of leaves and length of the leaves etc, when the plant is exposed to Indian Classical music. Physiognomic analysis for all the aforesaid characters was carried out after the treatment for 8 weeks. Multivariate analysis was conducted for the recorded observations by using several test statistics like Pillai's Trace, Wilks' Lamba, Hotelling's Trace and Roy's Largest Root. The physiognomy analysis carried out in plants with respect to the music as a parameter showed the significant result in week 2 and week 7.

Index Terms- Indian Classical *ragas*, synchronized sound waves, physiognomy analysis, multivariate analysis, test statistics

I. INTRODUCTION

1.1 Sound

Mechanical vibration is a form of oscillating energy that comprises of forces of specific frequencies that are repeated in a cyclic fashion [4]. It is transferred at the point of impact causing the back and forth or up and down motion known as vibration [4]. These vibrations that fall in the frequency range of hearing are called sound. As waves of energy causes vibrations, it possesses amplitude which can be referred to as wave strength as well as a frequency that is the number of oscillations of the wave per second [4]. Sound is a longitudinal, mechanical wave, simply a form of energy and moreover is a vibration (a transverse variation in pressure wave) [4].

1.2 Synchronized sound waves

Synchronized sound wave (music) is an ordered tonal or instrumental rhythmic sound. From its origins in the primitive as nature's sounds, it is the songs of birds, calls of animals, and waves of the ocean, sound of the breeze etc. Music is a melodious sound which is pleasing to our ears whereas sound which is not pleasant is known as noise [2]. The basic elements of music are rhythm, melody, harmony, pitch, tempo, dynamics, timbre, and referentially, the text of song as they form an important component of music therapy. These components exemplify qualities and attributes that have a contact singly, in different combinations, and as a gestalt [2].

Indian classical music is completely based upon a system of *ragas* [7]. Ragas are created by certain notes which convey definite emotions or ideas. These notes are selected with extreme care from the twenty two intervals of the *shruti* (or microtone)scale (smallest interval of pitch that a singer or musical instrument can produce and the human ear can detect) and then grouped to form a raga, a mode or a melodic structure of a time [7]. There are 22 *shrutis* out of which seven main notes have been formulated as *saptak*. The number of *shrutis* in each note are as follows : S:4 shruties R:3, G:2, M:4, P:4, D:3 and N:2 (Table 1.1). Structural melody is the most fundamental as well as important characteristic of Indian music [8]. Plainly, *raga* means to colour or to please, basically raga is a system of melody [8]. It is defined as a combination of notes, illustrated by melodic movements (varna), that is capable of producing pleasant sensations. *Raga* is a scientific, subtle, precise and aesthetic melodic form with its ascending and descending movement which consists of either a full octave or a series of five, six or seven notes [7]. A raga is the range of several notes woven into a composition which through aural perception soothes the heart and mind of the listener.

Table 1.1: Frequency ratios of 'shruti' values [11].

Shruti	**Frequency ratio (f=v/λ)**	**Frequency (Hertz)**
Sa	1/1	240
Re1	32/31	252.8
Re2	16/15	256
Re3	10/9	266.6
Re4	9/8	270
Ga1	32/27	284.4
Ga2	6/5	288
Ga3	5/4	300
Ga4	81/64	303.7
Ma1	4/3	320
Ma2	27/20	324
Ma3	45/32	337.5
Ma4	64/45	341.3
Pa	3/2	360
Dha1	128/81	379
Dha2	8/5	384
Dha3	5/3	400
Dha4	27/16	405
Ni1	16/9	426.6

Ni2	9/5	432
Ni3	15/8	450
Ni4	31/16	465

*Sa-*Shadja*, Re-*Rishab*, Ga-*Gandhar*, Ma-*Madhyam*, Pa-*Pancham*, Dha-*Dhaivat*, Ni-*Nishad* [11]

* V is the wave speed, λ is the wavelength of the wave [11]

There are two systems of scales in India they are, the South Indian or Karnatak music that has 72 primary scales called *melas*, produced by variations of seven fundamental notes (*shudhsvaras*- Sa, Re, Ga, Ma, Pa, Dha, and Ni) [13].
The North Indian or Hindustani music that has ten primary scales called *thaaths*. A *thath* is a group of notes from which raga can be formed. Each of the ten *thaaths* has the *raga* of the same name [13]. According to the laws of physics, a sound creates a number of vibrations and frequencies which can be measured and the relation between two sounds (pitches) is the ratio between their vibrations. Accordingly, S has 240 vibrations per second; R has 270, G-300, M320, P-360, D-400 and N-450 [13].
Hypothetically, the Indian Classical *Ragas* can also be scientifically classified like the living organisms and such classification can be referred to as Genesis. According to the genesis of Indian Classical *Ragas*, *Thaat* equals Class, the *Ragas* are equivalent to Family and theNotesmay be synonymous to species (Table 1.2).

Table 1.2: Origin of Indian Classical *Ragas* [1].

Name of *Thaat* (Class) [10]	**Some well-known *Ragas*of the corresponding *Thaat* (Family) [10]**	**Properties of *Notes* (species) of that *Ragas* [10]**	**Time of playing**
Bilawal	*Bilawal, Bihag, Durga, Hansdhwani*	All *shuddh* or natural notes	Almost all day
Kafi	*Kafi, Pilu, Bageshri, Mian ki Malhar*	Ga, Ni, *Komal*	Almost all the day
Asavari	*Asavari, Jaunpuri, Darbari, Kanada*	Ga, Dha, Ni *Komal*	Noon (10am-12am), Night (10pm-12am), Midnight (12am-2am)
Khamaj	*Khamaj, Jhinjhoti, Desh*	Ni *Komal*	Late evening (8pm-10pm)
Kalyan	*Kalyan, Shuddh Kalyan, Aiman*	No *Komal*, only *Teevra* Ma	Almost all day
Bhairav	*Bhairavi, Gauri, Lalit, Jogiya, Ramkali*	Re, Dha *Komal*	Early morning (6am-8am), Morning (8am-10am), Evening (6pm-8pm)
Bhairavi	*Bhairavi, Bilaskhani, Todi, Malkaus*	Re, Ga, Dha, Ni *komal*	Morning (8am-10am), Noon (10am-12am), Midnight (12am-2am)
Marwa	*Marwa, Jait, Vibhas,*	Re *Komal*, Ma *Teevra*	Almost all the day
|*Poorvi*	*Purvi, Shree, Basant*	Re, Dha *Komal*, Ma *Teevra*	Predawn (2am-4am), Dawn (4am-6am), Dusk (4pm-6pm), Evening (6pm-8pm)
Todi	*Todi, Multani, Gurjari Todi*	Re, Ga, Dha *Komal*, Ma *Teevra*	Morning (8am-10am), Dusk (4pm-6pm)

1.3 Synchronized sound waves in relation to plant life

Music speaks what cannot be spoken, soothes the mind and gives it rest, heals the mind and makes it complete flows from the heaven to the soul. Music saves life, gives life, and supports life. Sound and silence is the main form of music in the sense that with classical music notation, silence is normally represented by rest markings that are the moments in which nothing is played [12]. Synchronized sound waves of Indian classical music have been applied to plants at various growth stages. It is known to effect or stimulate the seed germination, flowering, fruiting and fruit ripening in several plants [6]. Further the exposure of plants to the sound enhances the defense mechanism of plants against several biotic and abiotic agents [14]. Sound waves can also act as a potent agent that can alter the cell cycle of the plant [14]. Several works and observations showed that plants respond to different types of music. It can show both detrimental and stimulatory effect in its expansion and development. Music styles with hard-core vibrations cause major detrimental effects on the plant growth and development [3]. Plants accept Indian classical music and showed an increased growth and development, which is well confirmed from our present experimental research work [9].

II. MATERIAL AND METHODS

2.1 Acoustic treatment selection

Synchronized sound waves (music) in the form of Indian classical Ragas were selected for the treatment. The sound exposure was given to plants in dose dependent and time dependent manner. Synchronized sound waves (music) in the form of Indian classical *Ragas* were selected for the treatment. The sound exposure was given to plants in dose dependent and time dependent manner. Specific ragas are associated with the time. They are to be sung at the specific time of a day to create specific influence as related to the same. The plants are subjected to the specific *raga* in a time dependent manner, that is the ragas are played for ten minutes and an intermittent break of ten minutes is given. The ragas used for the experiment were as follows:

**RagaBhairavi*- Flute (Closed pipe) by Pandit Hari Prasad Chaurasia (9:50) at early morning 7am-8am

**RagaKedar*- Flute (closed pipe) by Pandit Pannalal Ghosh (38:14) during late morning etween 10am-12pm, followed by-

**RagaKedar*- Santoor (stringed instrument) by Pandit Shiv Kumar Sharma (23:14) in the evening between 6pm-7pm,

**RagaRageshree*- Sitar (stringed instrument) by Nikhil Banerjee (29:15) in the evening between 7pm-8pm.

2.2 Physiognomy analysis

Several criteria for the physiognomy analysis were considered to study the effect of music in the form of Indian classical ragas. They are plant height, number of leaves, leaf length, leaf width, and plant spread in terms of east-west and north-south spread. The analysis of all the above-mentioned parameters was carried out in weekly basis for eight consecutive weeks. Newly propagated plants in both the cases (control and experimental) were considered for the analysis. Three plants were considered in either of the cases for the analysis. A thread was used to carry out all the measurements. It was then placed over a 60 cm long measuring tape and the measured data regarding the above-mentioned parameters were recorded. All the data were collected in triplicates. Descriptive statistical analysis and multivariate analysis was performed using SPSS for windows statistical software (SPSS Inc., USA).

III. RESULT AND DISCUSSION

3.1 Results

Chamaecostus cuspidatus, when subjected to Indian classical music, the results showed a difference that is there was an increment in the physiognomic characters of the treated plant as compared to the control (untreated) plant. The color and texture of the plants were found to be green and smooth respectively. The leaves of the control plants turned yellow and leaves of treated plant stayed green. The average number of leaves per plant in control was 12 and in treated were 13. The observations were presented in tables and figures in weekly manner. The possible explanation to an increment of the growth over the control might be the perception of sound vibration and relay on the extended signaling pathways leading to the overall increased growth of the plant and leaves.

Day 1

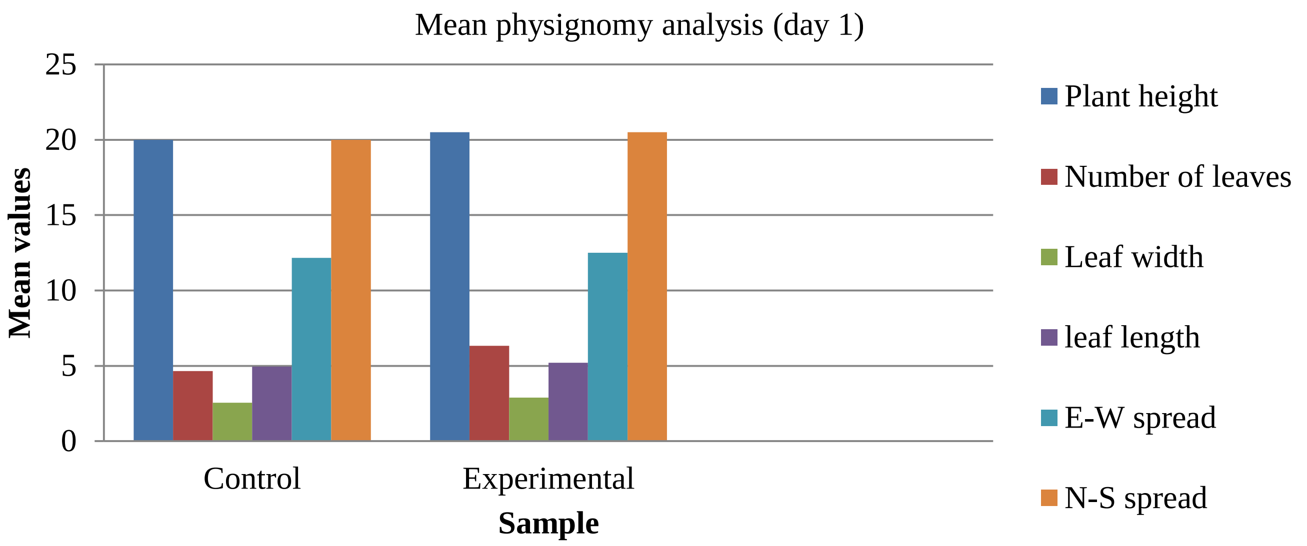

Figure 3.1: Mean physiognomy analysis (day 1).

Table 3.1: Multivariate analysis performed in *Chamaecostus cuspidatus* before treatment (Day 1).

Multivariate Tests[a]							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
SAMPLE	Pillai's Trace	0.860	1.534[b]	4.000	1.000	0.535	0.860
	Wilks' Lambda	0.140	1.534[b]	4.000	1.000	0.535	0.860
	Hotelling's Trace	6.135	1.534[b]	4.000	1.000	0.535	0.860
	Roy's Largest Root	6.135	1.534[b]	4.000	1.000	0.535	0.860

*F-F-test; df- degrees of freedom; Sig.- Significance

The mean analysis of all the data for day 1 is represented in the figure 3.1 that do not show much variation among the two sets. Multivariate analysis (Table 3.1) was conducted for the recorded observations by using several test statistics like Pillai's Trace, Wilks' Lamba, Hotelling's Trace and Roy's Largest Root. On the basis of the results the p-value is greater than 0.05 that is 0.535, thus the null hypothesis is accepted and the alternative hypothesis is rejected which suggested that there do not exist a significant difference in the two set prior to the treatment.

Week 1

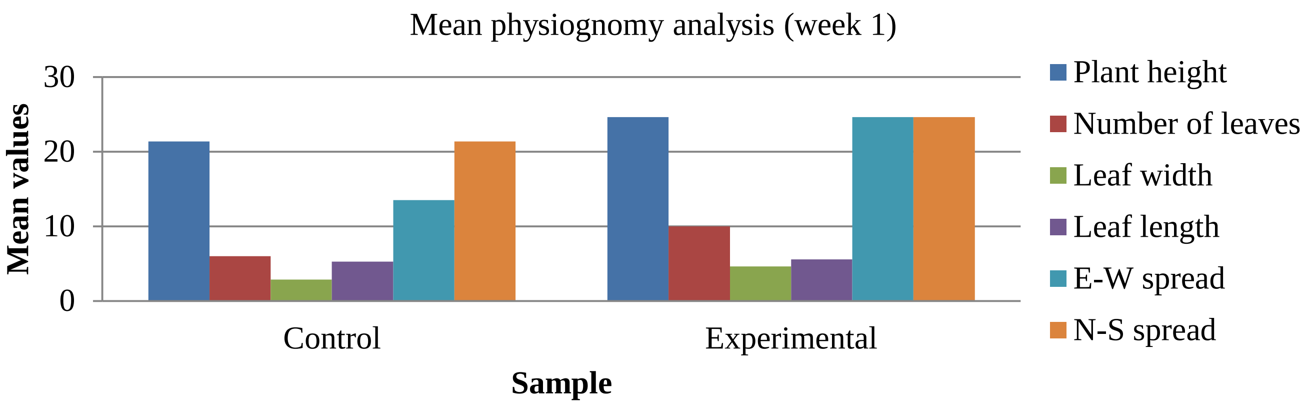

Figure `3.2: Mean physiognomy analysis (week 1).

Table 3.2: Multivariate analysis performed in *Chamaecostus cuspidatus* after treatment (week 1).

Multivariate Tests[a]							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
SAMPLE	Pillai's Trace	0.952	4.944[b]	4.000	1.000	0.324	0.952
	Wilks' Lambda	0.048	4.944[b]	4.000	1.000	0.324	0.952
	Hotelling's Trace	19.775	4.944[b]	4.000	1.000	0.324	0.952
	Roy's Largest Root	19.775	4.944[b]	4.000	1.000	0.324	0.952

The mean analysis of all the data for week 1 is presented in the figure 3.2 that showed maximal variation among the two sets in terms of plant height, Number of leaves E-W spread, N-S spread and minimal variations in other parameters. Multivariate analysis (Table 3.2) was conducted for the recorded observations by using several test statistics like Pillai's Trace, Wilks' Lamba, Hotelling's Trace and Roy's Largest Root. On the basis of the results the p-value is greater than 0.05 that is 0.324, thus the null hypothesis is accepted and the alternative hypothesis is rejected which suggested that there do not exist a significant difference in the two set (control and experimental) after the treatment.

Week 2

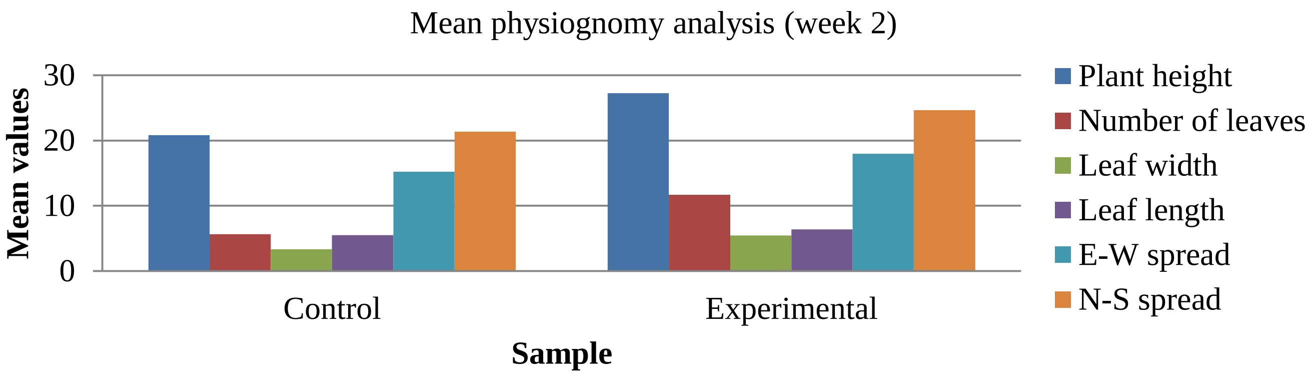

Figure 3.3: Mean physiognomy analysis (week 2).

Table 3.3: Multivariate analysis performed in *Chamaecostus cuspidatus* after treatment (week 2).

Multivariate Tests[a]							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
SAMPLE	Pillai's Trace	1.000	78246.641[b]	4.000	1.000	0.003	1.000
	Wilks' Lambda	0.000	78246.641[b]	4.000	1.000	0.003	1.000
	Hotelling's Trace	312986.563	78246.641[b]	4.000	1.000	0.003	1.000
	Roy's Largest Root	312986.563	78246.641[b]	4.000	1.000	0.003	1.000

The mean analysis of all the data for week 2 is presented in the figure 3.3, that showed much variation among the two sets in terms of plant height, number of leaves, E-W spread, N-S spread and as such. Multivariate analysis (Table 3.3) was conducted for the recorded observations by using several test statistics like Pillai's Trace, Wilks' Lamba, Hotelling's Trace and Roy's Largest Root. On the basis of the results the p-value is greater than 0.05 that is 0.003, thus the null hypothesis is rejected and the alternative hypothesis is accepted which suggested that there exist a significant difference in the two set (control and experimental) after the treatment.

Week 3

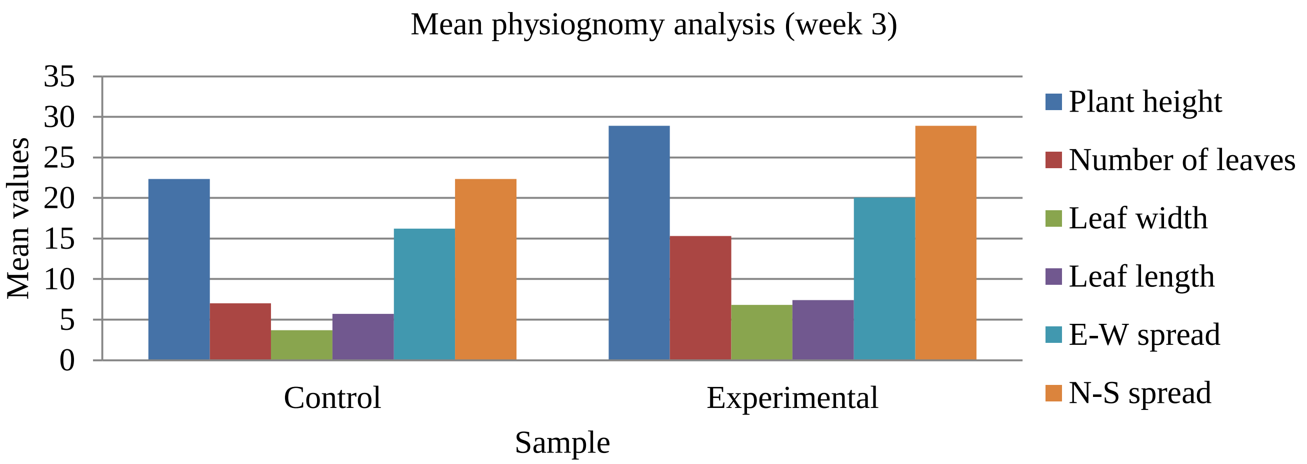

Figure 3.4: Mean physiognomy analysis (week 3).

Table 3.4: Multivariate analysis performed in *Chamaecostus cuspidatus* after treatment (week 3).

Multivariate Tests[a]							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
SAMPLE	Pillai's Trace	0.994	44.029[b]	4.000	1.000	0.112	0.994
	Wilks' Lambda	0.006	44.029[b]	4.000	1.000	0.112	0.994
	Hotelling's Trace	176.117	44.029[b]	4.000	1.000	0.112	0.994
	Roy's Largest Root	176.117	44.029[b]	4.000	1.000	0.112	0.994

The mean analysis of all the data for week 3 is presented in the figure 3.4 that showed little variation among the two sets in terms of plant height, Number of leaves, E-W spread, N-S spread and other parameters with comparison to week 2. Multivariate analysis (Table 3.4) was conducted for the recorded observations by using several test statistics like Pillai's Trace, Wilks' Lamba, Hotelling's Trace and Roy's Largest Root. On the basis of the results the p-value is greater than 0.05 that is 0.112, thus the null hypothesis is accepted and the alternative hypothesis is rejected which suggested that there do not exist a significant difference in the two set after the treatment.

Week 4

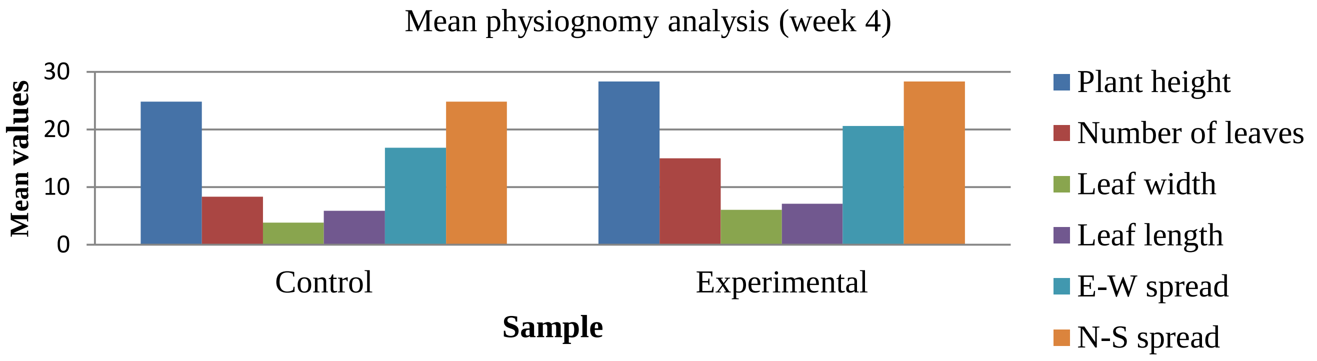

Figure 3.5: Mean physiognomy analysis (week 4).

Table 3.5: Multivariate analysis performed in *Chamaecostus cuspidatus* after treatment (week 4).

Multivariate Tests[a]							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
SAMPLE	Pillai's Trace	.857	1.494[b]	4.000	1.000	0.541	0.857
	Wilks' Lambda	.143	1.494[b]	4.000	1.000	0.541	0.857
	Hotelling's Trace	5.976	1.494[b]	4.000	1.000	0.541	0.857
	Roy's Largest Root	5.976	1.494[b]	4.000	1.000	0.541	0.857

The mean analysis of all the data for week 4 is presented in the figure 3.5 that showed maximum variation among the two sets in terms of plant height, number of leaves, E-W spread, N-S spread and minimum variations in other parameters with comparison to week 3. Multivariate analysis (Table 3.5) was conducted for the recorded observations by using several test statistics like Pillai's Trace, Wilks' Lamba, Hotelling's Trace and Roy's Largest Root. On the basis of the results the p-value is greater than 0.05 that is 0.541, thus the null hypothesis is rejected and the alternative hypothesis is accepted which suggested that there exist a significant difference in the two set (control and experimental) after the treatment.

Week 5

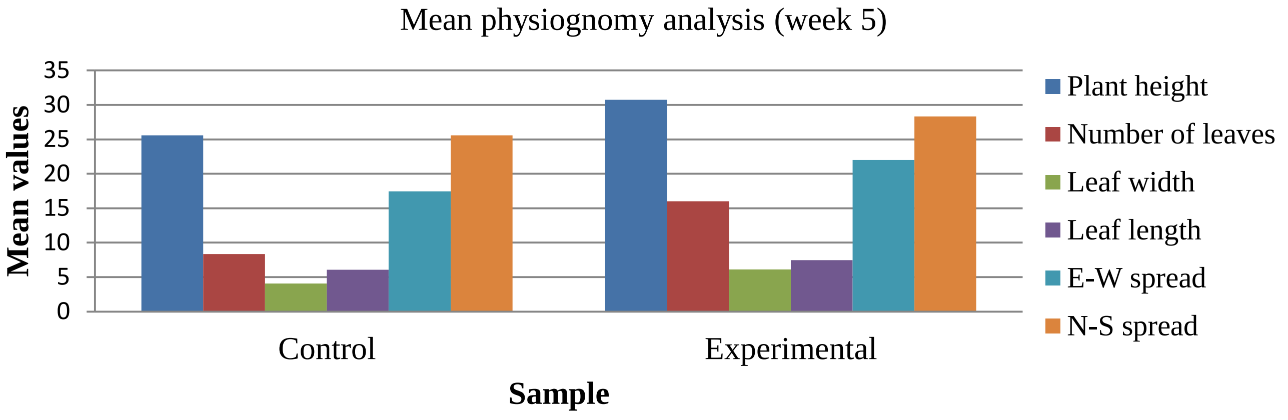

Figure 3.6: Mean physiognomy analysis (week 5).

Table 3.6: Multivariate analysis performed in *Chamaecostus cuspidatus* after treatment (week 5).

Multivariate Tests[a]							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
SAMPLE	Pillai's Trace	0.937	3.690[b]	4.000	1.000	0.370	0.937
	Wilks' Lambda	0.063	3.690[b]	4.000	1.000	0.370	0.937
	Hotelling's Trace	14.760	3.690[b]	4.000	1.000	0.370	0.937
	Roy's Largest Root	14.760	3.690[b]	4.000	1.000	0.370	0.937

The mean analysis of all the data for week 5 is presented in the figure 3.6 that showed maximum variation among the two sets in terms of plant height, number of leaves and minimum variations in other parameters with comparison to week 4. Multivariate analysis (Table 3.6) was conducted for the recorded observations by using several test statistics like Pillai's Trace, Wilks' Lamba, Hotelling's Trace and Roy's Largest Root. On the basis of the results the p-value is greater than 0.05 that is 0.370, thus the null hypothesis is rejected and the alternative hypothesis is accepted which suggested that there exist a significant difference in the two set (control and experimental) after the treatment.

Week 6

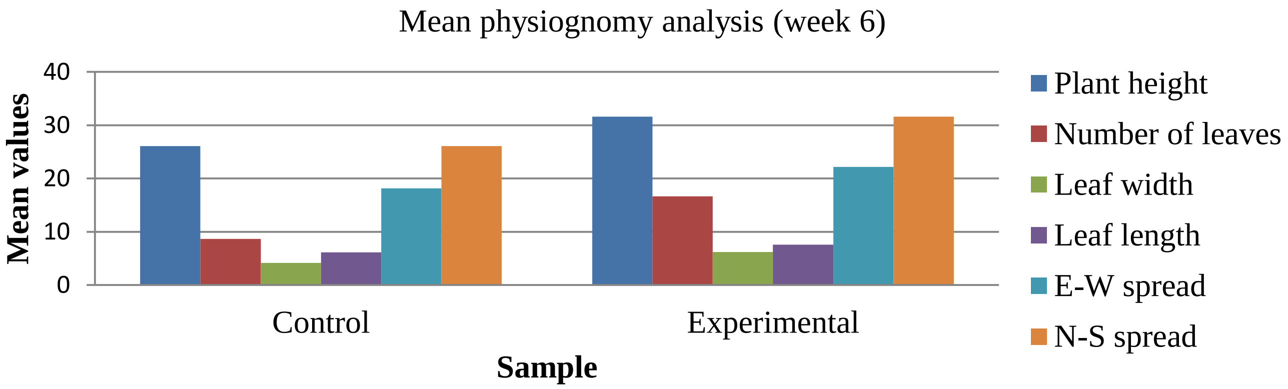

Figure 3.7: Mean physiognomy analysis (week 6).

Table 3.7: Multivariate analysis performed in *Chamaecostus cuspidatus* after treatment (week 6).

Multivariate Tests[a]							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
SAMPLE	Pillai's Trace	0.919	2.849[b]	4.000	1.000	0.415	0.919
	Wilks' Lambda	0.081	2.849[b]	4.000	1.000	0.415	0.919
	Hotelling's Trace	11.397	2.849[b]	4.000	1.000	0.415	0.919
	Roy's Largest Root	11.397	2.849[b]	4.000	1.000	0.415	0.919

The mean analysis of all the data for week 6 is represented in the figure 3.7 that showed maximum variation among the two sets in terms of plant height, number of leaves, N-S spread and minimum variations in other parameters with comparison to week 5. Multivariate analysis (Table 3.7) was conducted for the recorded observations by using several test statistics like Pillai's Trace, Wilks' Lamba, Hotelling's Trace and Roy's Largest Root. On the basis of the results the p-value is greater than 0.05 that is 0.415, thus the null hypothesis is rejected and the alternative hypothesis is accepted which suggested that there exist a significant difference in the two set (control and experimental) after the treatment.

Week 7

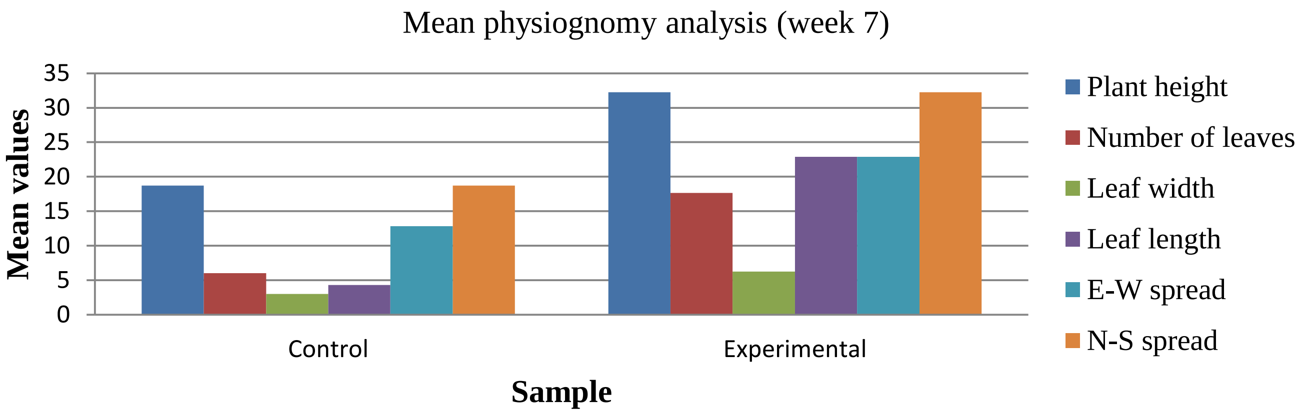

Figure 3.8: Mean physiognomy analysis (week 7).

Table 3.9: Multivariate analysis performed in *Chamaecostus cuspidatus* after treatment (week 7).

Multivariate Tests[a]							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
SAMPLE	Pillai's Trace	0.999	169.968[b]	4.000	1.000	0.049	0.999
	Wilks' Lambda	0.001	169.968[b]	4.000	1.000	0.049	0.999
	Hotelling's Trace	679.870	169.968[b]	4.000	1.000	0.049	0.999
	Roy's Largest Root	679.870	169.968[b]	4.000	1.000	0.049	0.999

The mean analysis of all the data for week 7 is represented in the figure 3.8 that showed maximum variation among the two sets in terms of all the parameters with comparison to week 6. Multivariate analysis (Table 3.8) was conducted for the recorded observations by using several test statistics like Pillai's Trace, Wilks' Lamba, Hotelling's Trace and Roy's Largest Root. On the basis of the results the p-value is greater than 0.05 that is 0.049, thus the null hypothesis is rejected and the alternative hypothesis is accepted which suggested that there exist a significant difference in the two set (control and experimental) after the treatment.

Week 8

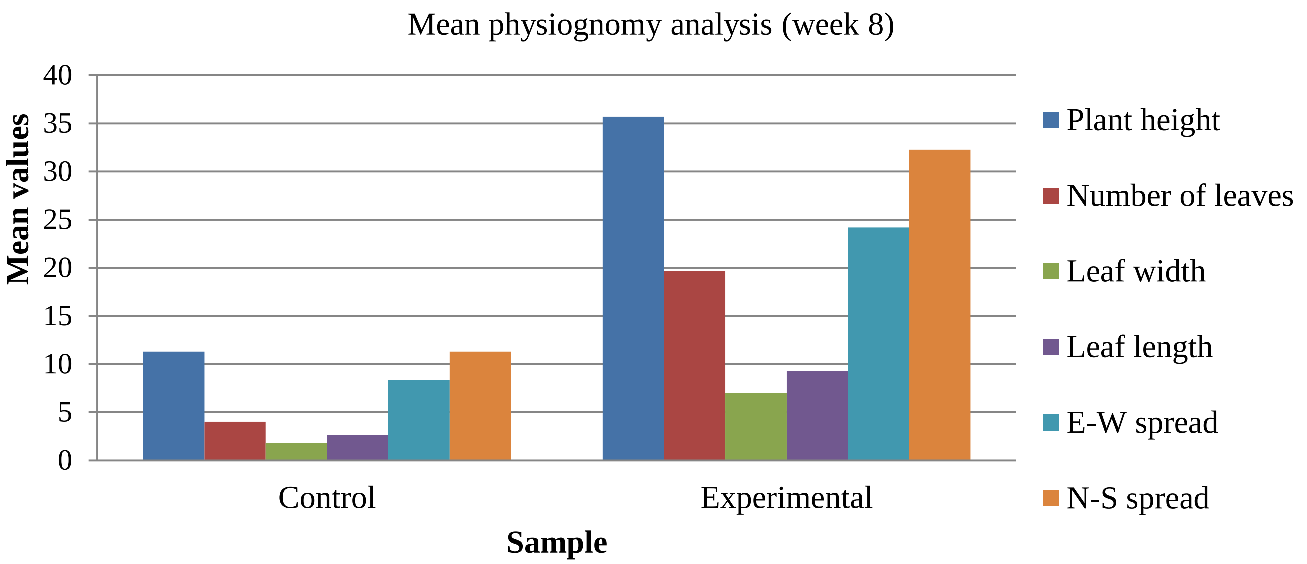

Figure 3.9: Mean physiognomy analysis (week 8).

Table 3.9: Multivariate analysis performed in *Chamaecostus cuspidatus* after treatment (week 8).

Multivariate Tests[a]							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
SAMPLE	Pillai's Trace	0.896	5.756[b]	3.000	2.000	0.152	0.896
	Wilks' Lambda	0.104	5.756[b]	3.000	2.000	0.152	0.896
	Hotelling's Trace	8.634	5.756[b]	3.000	2.000	0.152	0.896
	Roy's Largest Root	8.634	5.756[b]	3.000	2.000	0.152	0.896

The mean analysis of all the data for week 8 is represented in the figure 3.9 that showed maximum variation among the two sets in terms of all the parameters with comparison to week 7. Multivariate analysis (Table 3.9) was conducted for the recorded observations by using several test statistics like Pillai's Trace, Wilks' Lamba, Hotelling's Trace and Roy's Largest Root. On the basis of the results the p-value is greater than 0.05 that is 0.152, thus the null hypothesis is rejected and the alternative hypothesis is accepted which suggested that there exist a significant difference in the two set (control and experimental) after the treatment.

3.2 Discussion

Thus the physiognomy analysis carried out in plants with respect to the music as a parameter showed the significant result in week 2 and week 7. The marked difference between the two sets with respect to the parameters is not seen in other weeks morphologically. Synchronized sound waves in the form of Indian classical ragas when perceived by the plants showed the enhancement of overall plant growth. This plant growth is visible in the physiognomy characters such as plant height, north-south spread, and east-west spread, number of leaves and length of the leaves. There are certain mechano-sensitive ion channels that are capable of perceiving and responding to mechanical force (in this case the synchronized sound waves). The genes encoding those ions channels (MSL and MCA genes) are isolated in *Arabidopsis* plants [5]. These classes of mechanoreceptors are capable of transducing membrane tension directly into ion flux [5]. Till date three families of plant mechanosensitive ion channels have been identified. They are MSL, MCA and TPK families [5]. The mechano-sensitive ion channels from those families vary widely in their structure and functions, their localizations in different sub-cellular compartments and in their conduction of chloride, calcium and potassium ions [5]. When the extracellular forces are applied to the plants this results in the deformation of cellular membranes, where the force is perceived by those mechano-sensitive ion channels. These specialized ion channels are membrane spanning protein complexes that facilitates the flux of ions across the lipid bilayer that are responsible for a wide range of functions. The perception of force by those mechanoreceptors can be mediated through the actions of cytoskeletal reorganizations, nuclear deformations, and actions of integrins [5]. These changes can further be interpreted in the transcriptional and translational levels. Plants as a whole when exposed to the synchronized sound waves produce an increased amount of mRNA in the transcriptional level for a certain character which are further translated into the proteins that are expressed in the phenotypic character of the plant.

IV. CONCLUSION

Plants do absorb and reverberate to external frequencies in the form of sound waves especially the western and eastern classical music as conceptualized and established by Sir Jagdish Chandra Bose a Nobel Prize winner in 1977 [10]. The acoustic frequency technology promotes plant growth, increases production and improves quality of the plants. From the research work carried out on the effect of synchronized sound waves in the form of Indian classical ragas on *Chamaecostus cuspidatus*, it is very clear that it has a significant impact on the overall growth of the plant. *Chamaecostus cuspidatus*, when subjected to Indian classical instrumental music, the results showed a difference that is there was an increment in the physiognomic characters of the treated plant as compared to the control (untreated) plant. The significant result was marked in week 2 and week 7 of the 8 weeks of treatment period. This plant growth is visible in the physiognomy characters such as plant height, north-south spread, and east-west spread, number of leaves and length of the leaves. *Chamaecostus cuspidatus* has an herbal cure for diabetes. By consuming the leaves, the blood glucose level is generally lowered; hence it is commonly called as insulin plant. Beside this the plants do have several other medicinal properties like it is used to treat abdominal pain, jaundice, fungal infection, bacterial infection, diarrhea, fever and many more. The whole plant (leaves and rhizomes especially), posses secondary metabolites such as diosgenin, corosolic acid, quercetin, catechine, oleic acid that shows anti-diabetic activity and is used in the treatment of diabetes. Sound waves technology has emerged as a new potential trigger for plant protection against biotic stress like disease causing pests and pathogens. This can be extended by the practical applications of such technology and its further analysis. It can be further used to enhance the growth of the plant and their production worldwide by utilizing it in nurseries and farms. Simultaneously we can think of lowering the soil pollution that is caused due to the use of toxic chemical fertilizers and pesticides as this technology can be beneficial for the agricultural sectors by increasing the productivity without depending on the chemical fertilizers.

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References

[1] Bazmi N, Khan WA, Shahzaad S, Khan N. Sargam lessons: Sa, Re, Ga, Ma. Virtual Music Publications Pvt Ltd. 2004; 6-108.

[2] Chivukula V,Ramaswamy S. Effect of different types of music on *Rosa Chinensis* Plants. International Journal of Environmental Science and Development. 2014; 5:431-434.

[3] Chowdhury AR, Gupta A. Effect of music on plants-An overview. International Journal of Integrative Sciences, Innovation and Technology 2015; 4, 30-34.

[4] College Physics- Third Edition, Manning, Kennth V, Weber, Robert L, White, Marsh W, Weygand, George A. Published by McGraw-Hill Education; 1974.

[5] Ghosh R, Gururani MA, Ponpandian LN, Mishra RC, Park SC& Jeong MJ. Expression analysis of sound vibration regulayted genes by touch treatment in *Arabidopsis* Front. Plant Sci. 2017; 8:100.

[6] Harborne AJ. Phytochemical methods a guide to modern techniques of plant analysis. Chapman and Hall. New York. 1998; 81-88.

[7] Mansukhani GS. Indian classical music and sikh kirtan, (http://www.freeyellow .com/members2/tabla/). 1982; 23-5-13.

[8] Motwani, India: A synthesis of cultures, Publisher: Thacker.1947; 78-95.

[9] Padhi S, Swain R& Rout PP. Impact of Harmonic Octave consonants (classical musical notes) on the discrete physiognomic characters and different biochemical aspects in sweetleaf viz., *Stevia rebaudiana* (Bertoni). International Journal of Plant Animal Environmental Sciences. 2022b;12(2): 044-058.

[10] Padhi S, Rout PP & Swain R. Effect of synchronized sound waves in the form of Indian classical Ragaas on phytohormonal analysis of medicinal plant species. Scholars Academic Journal of Biosciences. 2022a; 10(3):1-7.

[11] Shah N. Visualization of Indian Classical Music: A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Technology. Department of Computer Science and Engineering. Indian Institute of Technology, Kanpur. 2001; 1-61.

[12] Sharma D, Gupta U, Fernandes AJ, Mankad A & Solanki HA. (2015). The effect of music on physic-chemical parameters of selected plants. International Journal of Plant, Animal and Environmental Sciences. 2015;5(1):282-287.

[13] Thakkar MG &Kajal C. Science of ragas: the control on living beings to the cosmic elements. Journal of Environmental Research And Development. 2014; 9(1): 260-270.

[14] Wang SY, Jiao H. Correlation of antioxidant capacities to oxygen radical scavenging enzyme activities in blackberry. Journal of Agricultural and Food Chemistry.2000;48: 5672-5676.