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Effects of harmonic Octave Consonants (Classical Musical Notes) on seed germination in four different plant species viz; *Phaseolus vulgaris* L., *Vigna radiata* L. Wilczek, *Phaseolus lunata* (Wakker), *Lathyrus aphaca* L.

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Abstract

Music is an integral part of our nature and society. The harmonic octave consonants and their frequencies are now-a-days used as a therapy, being popularly called as music therapy. However, the impact of music on our physical and physiological processes has been acknowledged since ages. Rhythmic and comforting music has an influence on physical and physiological conditions and behavior of living organisms such as humans, plants and animals. According to various studies, Indian Classical music has been confirmed to encourage plant growth positively and it is seen to dominate the other important genres of music such as western classical, rock, country music and monotonous sounds. The present research work is aimed at finding the exclusive impact and effect of the harmonic octave consonants and their frequencies in different strings and closed-pipe Indian classical instrumental music displayed through various *Ragaas*, viz: *Raga Kedar* (flute), *Raga Kedar* (santoor), *Raga-Rageshree* (sitar), *Raga-Bhairavi* (flute), *Raga- Shree* (Sarangi), *Raga- Milan ki Todi* (Sarod), *Raga- Ramkali* (Sitar) on seed germination process in four different plants species viz; *Phaseolus lunatus*, *Lathyrus aphaca*, *Phaseolus vulgaris* and *Vigna radiata*.

Keywords: Music therapy, Indian Classical *music*, Harmonic octave consonants, Strings and closed-pipe, Seed germination

Abbreviations: Hz-Hertz, I-Sound Intensity, L-Sound Intensity Level, Db- Decibel

1. Introduction

1.1 Sound

Sound is a form of energy. It is a compressional wave triggered by vibrations (Wood, 1976). The vibrations that are felt on touching the surface of a speaker are equal to the vibrations disturbing the air. Sound is similar to countless other things which are invisible in our universe. It cannot be seen as well but sound can be heard as it reaches our ears in the form of waves produced when particles in the medium vibrates

(Rigden, 1977). Hence, vibration in a body generates sound. Sound is a form of energy that produces the sensation of hearing in our ears. For instance, when a string is stretched by holding one end in our mouth and the other end in one hand then on plucking the string near middle, it is noticed that the string starts vibrating and simultaneously a sound is heard (Burridge et al. 1982). The sound ceases to be heard as soon as the string stops vibrating. Similarly, when the string of a sitar or guitar is plucked then the string starts vibrating and its sound is heard. In order to start vibrations in the sound-producing body, mechanical energy is required (Moore, 2006). The source of sound produces vibrations and these vibrations are transmitted in the form of waves from that point to the next and this process continues until the termination of vibration.

1.2 Characters of sound associated with music

The propagation of sound from one place to another requires a material medium as it cannot travel through vacuum (Goldstein, 1966). The different components of sound include amplitude, frequency, wavelength, tone (Lapp, 2002).

Amplitude can be defined as the maximum displacement of the particle of the medium on either side of its mean position during its transmission through the medium. It is measured in meter. The intensity of the sound is directly proportional to amplitude i.e., the intensity is high when the amplitude is high and vice versa. The second component is frequency, which is the number of vibrations made by the particle of the medium in one second. It is measures in hertz (Hz). Pitch helps to distinguish between low and high sounds and it depends upon the frequency of the wave particles. In common practices we can easily distinguish between male and female voices due of different pitch. Humans are able to hear the frequencies of 20-20,000 Hz; this range is referred to as the audible sound or sonic sound. Sounds above the audible range is called the ultrasonic sound and below the audible range is called infrasonic sound. Sounds above or below this range is not perceived by humans but few animals can hear the frequencies above and below the audible range. The third component is wavelength that is usually determined by considering the distance between two consecutive corresponding points of the same phase such as crests and troughs. The fourth component of sound is the tone and harmonics. This third component is related to pleasing and unpleasing sound.

1.3 Music

Music and noise are two different things; the former has a soothing effect and the latter is infuriating. Music is related to rhythmic and periodic vibrations while noise has no periodic vibrations (Lapp, 2002). Music for about a thousand of years have been a source of harmony for people. Music is a soothing and tranquilizing form that is produced from musical instrument. Music is a fine art of sound and is basically prearranged by people for many reasons like, to dance to, to speak a story, to make other people feel a certain way, or just to sound pretty or be entertaining.

Every individual in this world now is relieving their stress just by tuning into their favorite songs and so much is their affinity towards music that it acts as a therapy for them and we can simply call it as music therapy. Music therapy is the achievement of customized goals within a therapeutic association by the medical and evidence-based practice of music intrusions involving a qualified expert who has accomplished a permitted music therapy program (Crowe and Colwell, 2007). Music certainly has many dimensions and so it is successful in stirring various physical, psychological, spiritual and social stages of awareness (Kneafsey, 1997). Currently, music is categorized as both positive and negative. Music that has valuable potentials and inspires at emotional and spiritual levels and causes relaxing, calming and healing effects is known as **positive music** whereas **negative music** induces negative emotions, irritation, bitterness, sadness, animosity and terror (Ekici et al. 2007).

1.4 Octave

Octave which can simply be known as a doubling in frequency (40 Hz is one octave greater than 20 Hz) is one dynamic conception related to music. According to Shah (2001), the several 'octaves' has been arranged on the basis of audible sound range and depending on some mathematical principles, an individual octave has been classified into intervals. In Western music, an octave is categorized into twelve parts , which is the width of a semitone, i.e. the frequency ratio of the interval between two adjacent notes that is the twelfth root of two and is mathematically expressed as (Kuttner, 1975):

$^{12}\sqrt{2} = 2^{1/2} \approx 1.059463$, which is again equivalent to

$e^{1/2 \ln 2} \approx 1.059463$

This interval is divided into 100 cents. An equivalent of octave in Indian Classical Music is *Saptak* that is a constituent of twenty-two tones stated to as '*Shruti*'. The seven pure notes in Indian Classical Music are called '*shuddha swaras*' and are composed by the microtones i.e. *shrutis* showing distinct frequency range (table 1 and table 2).

Table 1. Frequency ratios of 'shruti' values (Source: Shah, 2001)

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* and *Ni - Nishad*, f-frequency ratio, v- speed, λ-lambda

Table 2. The notes in an octave in Indian Classical Music vs Western music

Note name	Notation ID	Solfa Syllable	Western Equivalent	Full Name
sa	S	sa	Unison	shadja
komal re	r	re	Minor second	komal rishaba
shuddha re	R	re	Major second	shuddha rishaba
komal ga	g	ga	Minor third	komal gāndhāra
shuddha ga	G	ga	Major third	shuddha gāndhāra
shuddha ma	m	ma	Perfect fourth	shuddha madhyam
tivra ma	M	ma	Augmented fourth	tivra madhyam
pa	P	pa	Perfect fifth	panchama
komal dha	d	dha	Minor sixth	komal dhaivata
shuddha dha	D	dha	Major sixth	shuddha dhaivata
komal ni	n	ni	Minor seventh	komal nishāda
shuddha ni	N	ni	Major seventh	shuddha nishāda
sa	S'	sa	Octave	shadja

Sa - Shadja, *Re - Rishab*, *Ga - Gandhar*, *Ma- Madhyam*, *Pa – Pancham*, *Dha- Dhaivat* and *Ni - Nishad*

1.5. Background Story

After the first concept of perception of sound waves by plants as suggested by Sir Jagdish Chandra Bose, an Internationally acclaimed Indian Physicist and Plant Physiologist and a Nobel Prize winner in 1977, who was renowned for his work on the physiology of plants. Bose mentioned about how well plants responded to pleasant music and mild undertones, thus growing more quickly. When subjected to harsh music and loud speech, plants showed deprived growth. Ever since the 1970s, plants have also been exposed to almost all kinds of music.

A Colorado, USA undergraduate, Dorothy Retallack carried out one of the first experiments in 1973 to study the relationship between plants and music. While plants loved certain type of music like Mozart's music which has been proved to be their favorite because it allowed them to grow well whereas other music type caused their death. Various styles of music were used by Retallack in her experiment and she discovered that the plants showed a tendency to move away from Led Zeppelin and Jimi Hendrix but Bach organ music and jazz attracted them. Nevertheless, she found that North Indian classical music played on the *Sitar*, an Indian string Instrumental music, was their favorite but country music was seen to have no such relevance in plant life (Rettalack, 1973).

All living beings whether animals or plants respond to some sort of stimuli. Plants are multicellular organisms and respond to various types of external stimuli. Sound being a vibration is also perceived by plants as an external-stimuli. These vibrations stimulate different phytochemical and biochemical reaction in plants which in turn helps in their growth and development. Animals have ears to hear different sound but plants, basically perceive and sense it. Sound waves set up vibration on our ear drum which in turn is perceived by the brain and help us to recognize that it is a sound of varying frequencies and amplitude. Plant even in a similar way receive vibrations through protoplast. Numerous studies related to the effects of subjecting seeds and plants to sound waves, which is generally stated to as sonication, has been seen in scientific literature (Suslick, 1989; Joersbo and Brunstedt, 1992).

A sequence of five experiments was done to study the effects of music, noise, and curing energy without the use of human likings or try-on effects on seed germination (Creath and Schwartz, 2004), by making use of the okra (*Abelmoschus esculentus*), and zucchini (*Cucurbita pepo*) seeds. These seeds were germinated in an acoustically isolated, thermally insulated, dark, moist growth chambers. For comparison situations such as untreated control, musical sound, pink noise, and healing energy were taken. The seed germination containers were checked for temperature and relative humidity in every 15 minutes. An overall trial of 14 was carried out taking a total of 4600 seeds. Regarding the statistics and considering the results independent of temperature, seed type, location in the room, particular petri dish, and individual doing the scoring, musical sound was found to be having extremely substantial influence on the number of seeds sprouted in comparison to the untreated control above all five experiments for the main condition (p, 0.002) and over time (p, 0.000002) and it was thus concluded that sound affects living biologic systems.

2. Materials and methods

2.1 Materials

A total of four glass chambers were taken. Out of the four chambers, one chamber was the bigger one, measuring 25×18 inches while the other three were small and of same size i.e., 18×16 inches. There were holes built in two (one big glass chamber of 25×16 inches and the other small glass chamber of 18×16 inches) of the four glass chambers. The two glass chambers bearing holes with one on each of its four sides were used as "experimental" whereas the remaining two small glass chambers (devoid of holes) were designated as "control". The reason for the presence of holes in the experimental boxes was to allow the exchange of air for the growth of the plants because these two boxes were provided with a lid on their top to provide a fairly closed environment for our experiment. The other two "control" boxes had no lid on their top.

2.2 Plant materials

Seeds of four varieties viz; lima bean [*Phaseolus lunata* (Wakker)], yellow pea (*Lathyrus aphaca* L.), common bean (*Phaseolus vulgaris* L.) and mung bean (*Vigna radiata* L. Wilczek) were collected from a nursery near high court Square and used for experimental purposes.

2.3 Sound System

Two small portable multi-channel speakers having the main unit of frequency 50 Hz-200 Hz and two satellite units (with a frequency range of 200 Hz-18 KHz) were used to offer different harmonic frequencies of octave used in Indian Classical Instrumental Music (Through *Ragas*) in a 'time-dependent' and 'dose-dependent' manner to the plants used in the experiments. The two satellite speakers were actually used and these were operated by playing the music at about 90 decibels. The two portable speakers were connected to the CPU of the computer so that it would be easy to operate the speakers in order to play the music at required time intervals. This instrumental music was played in a "dose dependent" aa "time dependent".

Dose-dependent manner pertains to the frequency or number of times the plants have been subjected to *ragas* (Indian Classical Music). In contrast, time-dependent manner relates to the one-hour time interval given between the two hours of continuous music applied throughout the day.

2.4 Soil

Eight plastic glasses for seed germination with four each for treated and control separately were taken. A generous amount of alluvial soil was collected from the *Kathajodi* Riverside to use and conduct this experiment.

2.5 Arrangement of the Experiment

The glass chambers were acoustically isolated, thermally insulated and sufficiently illuminated, moist growth chambers with their temperature maintained at normal room temperature in Indian climate (25-27°C). The location of the room is the "Acoustic and Biochemistry Laboratory", Ravenshaw University, Cuttack, with a latitude of 20.47875^0 N and 85.85645^0 E of longitude. Before the experiments were conducted, the collected alluvial soil was groomed in the plastic glasses and plastic pots arranged for the experiments. Then the selected healthy seeds from each variety were taken and soaked in water overnight to absorb sufficient moisture to facilitate proper germination. The next day in the morning, the seeds were removed from the water and placed in a wet cloth to enhance germination of the seeds. A total of 80 seeds were sowed in plastic glasses and out of this, 10 seeds from each of the four varieties were designated as "experimental" and the 10 seeds from each of the four varieties were marked as "control". Equal amount of water was sprinkled on all the plastic glasses after which the "experimental" ones were kept in the experimental Acoustic chambers while the other box without the lid contained the "control" plastic glasses. The four glass chambers (both experimental and control were kept in a sound proof room provided with a fluorescent tube light to be a source of light for the plants; thereby, following a uniform environmental condition i.e light and temperature. The number of days taken by the seeds for germination was observed. For the early germination of seed the 'Bilambit' (slow) or 'Drut' (rapid) harmonic frequency of strings (Sitar/ Santoor) and closed pipe (eg: flute) were used.

2.6 Musical notes (Octaves)

The application of the Indian Classical Instrumental music notes (Octaves) through different *Ragaas* were applied to our experimental plant sets in the following time sequence

1. *Raga Kedar*- Flute (closed pipe) by Pandit Pannalal Ghosh (38:14) during early morning between 6am-8am, followed by-

2. *Raga Kedar*- Santoor (stringed instrument) by Pandit Shiv Kumar Sharma (23:14) in the Morning time between 10am-12pm,

3. *Raga Rageshree*- Sitar (stringed instrument) by Nikhil Banerjee (29:15) in the evening between 4pm-6pm followed by-

4. *Raga Bhairavi*- Flute (closed pipe) by Pandit Hari Prasad Chaurasia (9:50)

Result

Several studies including our recent results have proved that there is a curious association between music and plants and that both are profoundly interconnected to each other. Four different plant types viz; lima bean [*Phaseolus lunata* (Wakker)], yellow pea (*Lathyrus aphaca* L.), common bean (*Phaseolus vulgaris* L.) and mung bean [*Vigna radiata* L. Wilczek) were chosen. To perform the experiment, 4 sets each with 10 seeds were taken with one set up for control and another for experimental purpose. A total of 5 days were taken into consideration to observe the number of seeds germinated in each experimental set (total of four sets with 10 seeds each) and consequently, the data of the experimental set was compared with that of the 4 control sets (each with 10 seeds) (Table 1; Figure 1, Figure 2, Figure 3 and Figure 4).

Table 1. Effect of Indian Classical *Ragaas* on seed germination process in four different plant species

Serial number	Set name	Seed type	Day and number of seeds germinated
			1 2 3 4 5
1	Treated	*Phaseolus vulgaris*	- 1 2 4 7
		Phaseolus lumata	- 1 3 5 6
		Vigna radiata	- 2 2 4 5
		Lathyrus aphaca	- 2 3 5 8
2	Control	*Phaseolus vulgaris*	- - 1 2 3
		Phaseolus lumata	- - 1 2 4
		Vigna radiata	- 1 1 2 4
		Lathyrus ahpaca	- 1 1 2 3

Fig 1. Germinated seeds of *Phaseolus vulgaris* and *Vigna radiata* treated with Indian classical ragas (treated ones).

Fig 2. Germinated seeds of *Phaseolus vulgaris* and *Vigna radiata* treated with Indian classical ragas (control ones).

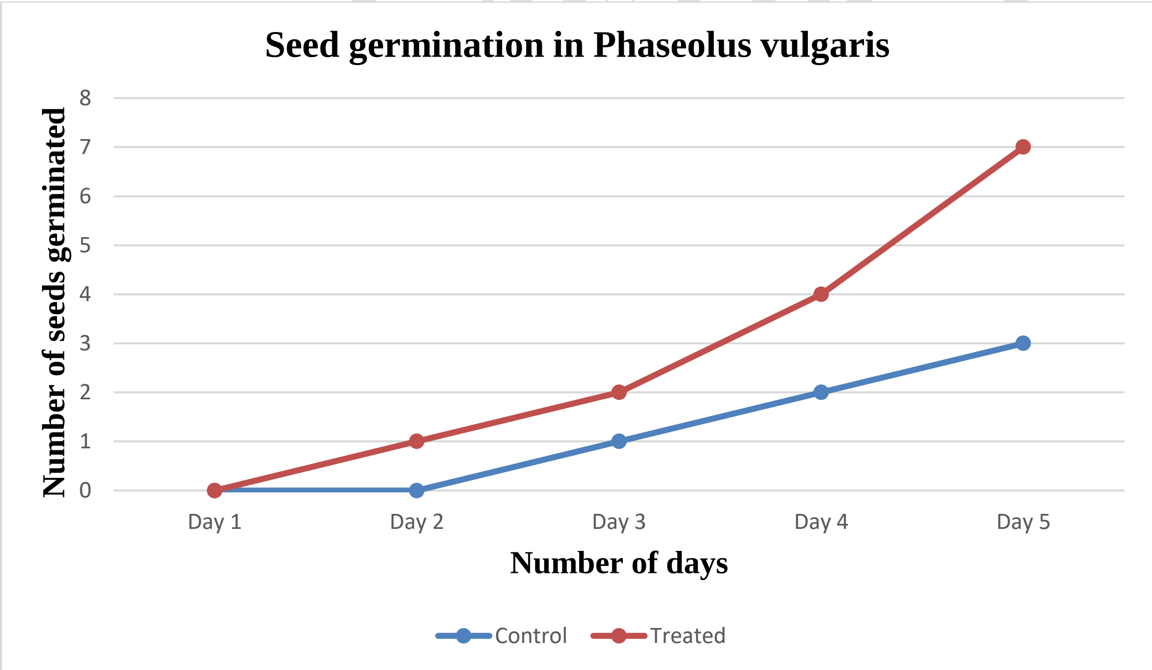

Fig 3. Graph representing the number of seeds germinated to the number of days in common bean (*Phaseolus vulgaris*)

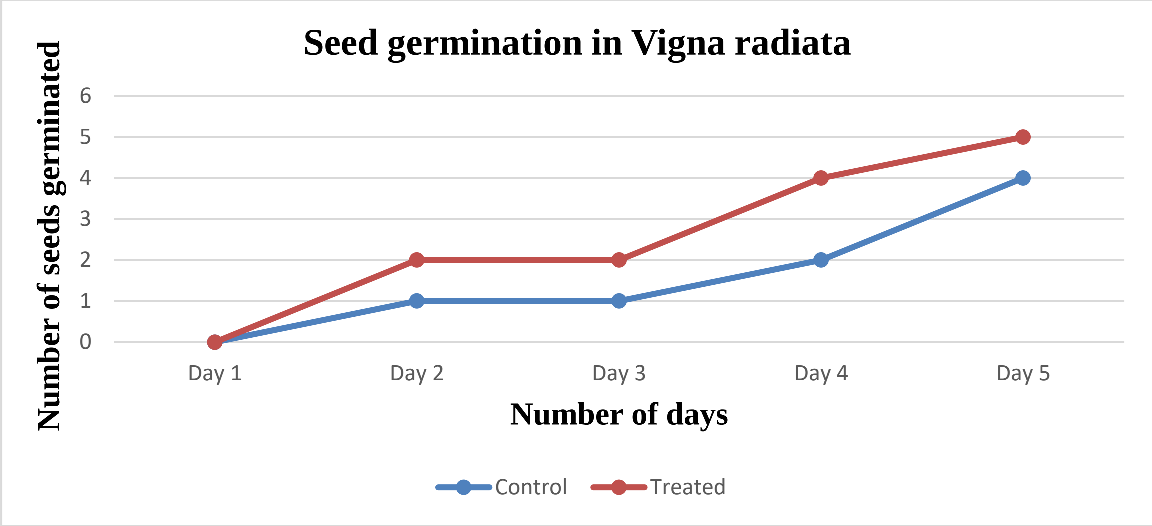

Fig 4. Graph representing the number of seeds germinated to the number of days in mung bean (*Vigna radiata*)

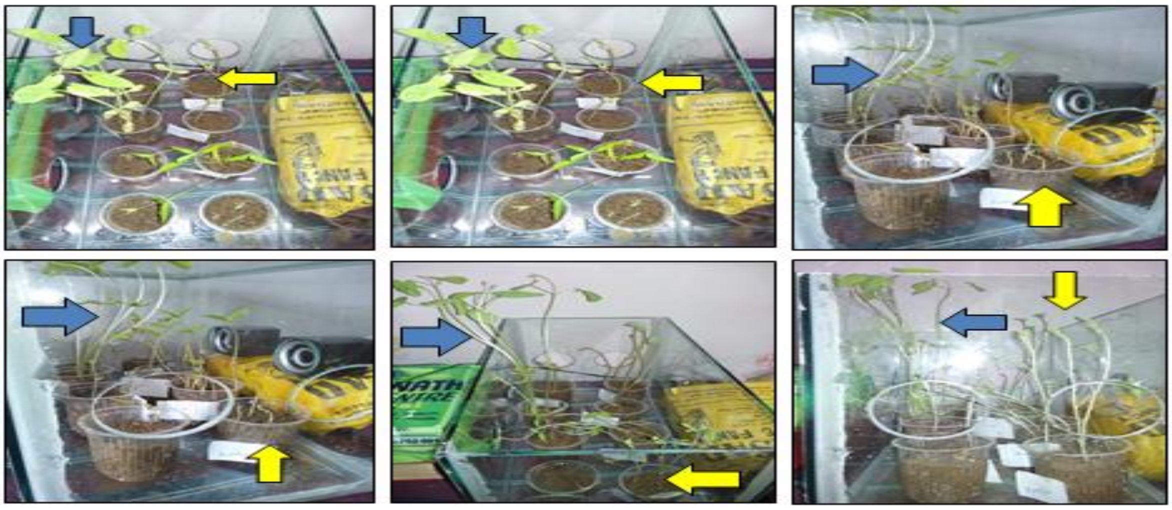

Fig 5. Germinated seeds of lima bean (*Phaseolus lunata*) and yellow bean (*Lathyrus aphaca*) treated with Indian classical *Ragaas* (treated one). The arrows in blue and yellow color represent the seedling of lima bean (*Phaseolus lunata*) and yellow bean (*Lathyrus aphaca*) respectively in the above given figure.

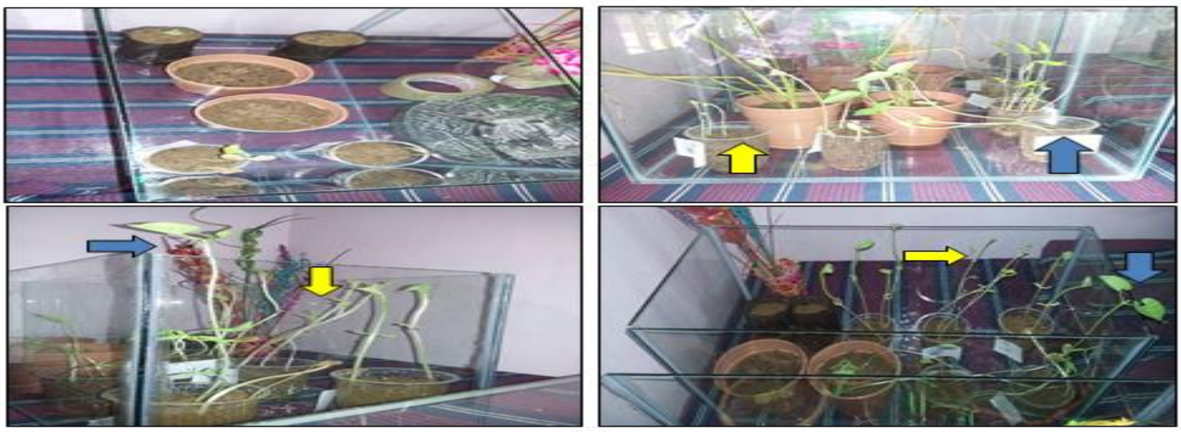

Fig 6. Untreated germinated seeds of lima bean (*Phaseolus lunata*) and yellow bean (*Lathyrus aphaca*) (control ones). The arrows in blue and yellow color represent the seedling of lima bean (*Phaseolus lunata*) and yellow bean (*Lathyrus aphaca*) respectively in the above given figure.

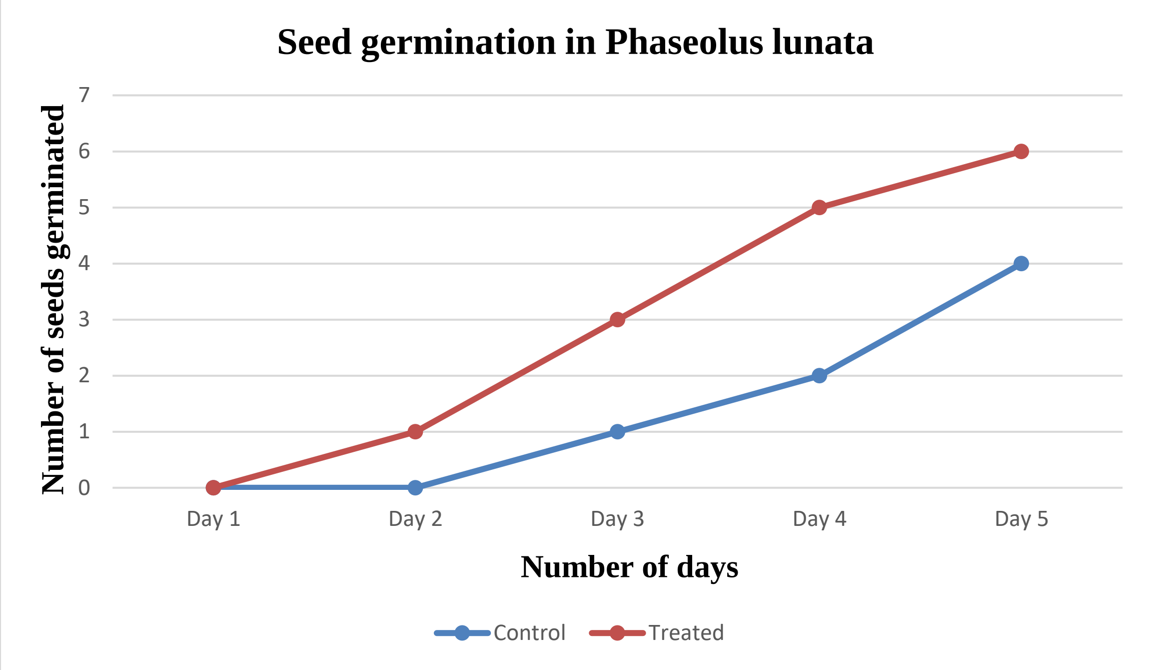

Fig 7. Graph representing the number of seeds germinated to the number of days in lima bean (*Phaseolus lunata*)

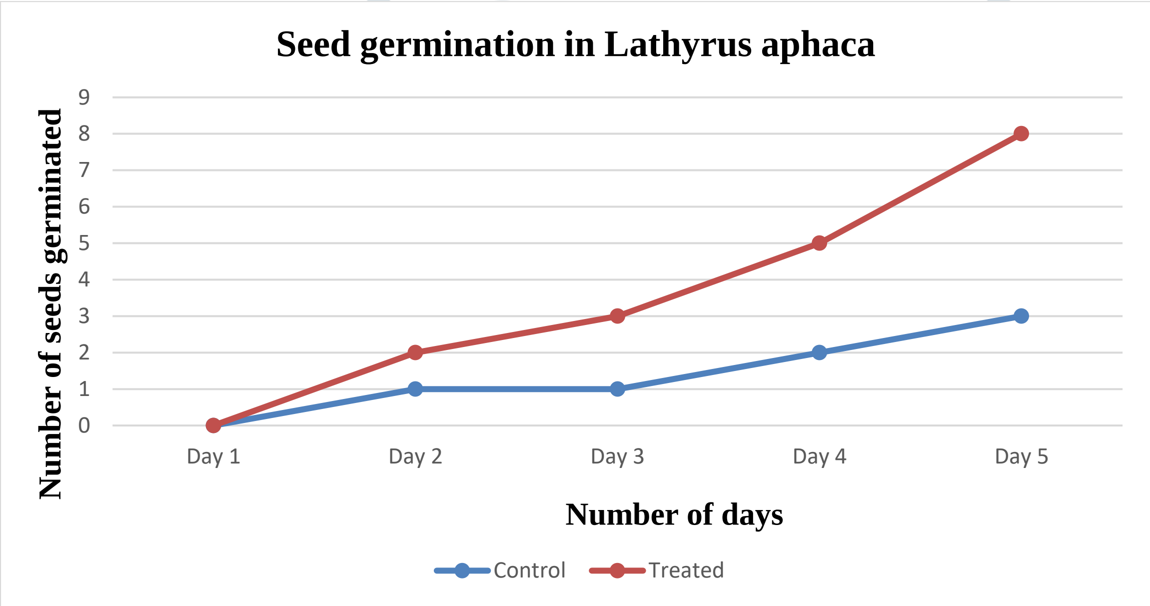

Fig 8. Graph representing the number of seeds germinated to the number of days in yellow pea (*Lathyrus aphaca*)

5. Discussion

In the present research work, seeds of lima bean [*Phaseolus lunata* (Wakker)], yellow pea (*Lathyrus aphaca* L.), common bean (*Phaseolus vulgaris* L.) and mung bean (*Vigna radiata* L. Wilczek) were subjected to Raga Kedar (pure tones) played by Flute (closed pipe) by Pandit Pannalal Ghosh (38:14) during early morning between 6am-8am, followed by Raga Kedar played by Santoor (string) by Pandit Shiv Kumar Sharma (23:14) in the Morning time between 10am-12pm) In the evening between 4pm-6pm, seeds were again exposed to Raga Rageshree played by Sitar (string) by Nikhil Banerjee (29:15) followed by Raga Bhairavi- Flute by Pandit Hari Prasad Chaurasia (9:50) during night between 8pm-10pm. It was observed that germination occurred much earlier than the control one which was treated with music. All the *Ragaas* were used in the form of instrumental music. Hence, it was confirmed that the Indian classical *ragas* enhanced the germination of seeds much earlier as compared to the usual time taken for these seeds to germinate (Recek et al. 2021). The treated seeds even grew much healthier than the control ones as observed in the data given below in tabular form (table 1, table 2, table 3, table 4, table 5, table 6, table 7, table 8).

Table 1. Seedling characters observed without treatment (control) with musical notes in common bean (*Phaseolus vulgaris*)

Day	Radicle	Plumule	Cotyledon leaves		
	Length (in mm)	Length (in mm)	Length (in mm)	Breadth (in mm)	appearance
48 hrs	12	2	10	8	small
72 hrs	22	3	13	8.5	small
96 hrs	26	7	19	10	medium
5th day	35	10	28	14	medium

Table 2. Seedling characters observed after treatment (treated) with musical notes in common bean (*Phaseolus vulgaris*)

Day	Radicle	Plumule	Cotyledon leaves		
	Length (in mm)	Length (in mm)	Length (in mm)	Breadth (in mm)	appearance
48 hrs	20	4	12	11	small
72 hrs	32	6	18	14	medium
96 hrs	44	12	22	18	medium
5th day	62	18	35	25	Medium-large

Table 3. Seedling characters observed without treatment (control) with musical notes in mung bean *(Vigna radiata)*

Day	Radicle	Plumule	Cotyledon leaves		
	Length (in mm)	Length (in mm)	Length (in mm)	Breadth (in mm)	appearance
48 hrs	14	0.6	6	4	small
72 hrs	18	2	8	7	small
96 hrs	21	5	12	15	medium
5th day	26	8	18	17	medium

Table 4. Seedling characters observed after treatment (treated) with musical notes in mung bean *(Vigna radiata)*

Day	Radicle	Plumule	Cotyledon leaves		
	Length (in mm)	Length (in mm)	Length (in mm)	Breadth (in mm)	appearance
48 hrs	17	3	8	5	small
72 hrs	22	7	12	9	small
96 hrs	28	9	15	16	medium
5th day	33	12	25	22	Medium-large

Table 5. Seedling characters observed without treatment (control) with musical notes in lima bean *(Phaseolus lunata*)

Day	Radicle	Plumule	Cotyledon leaves		
	Length (in mm)	Length (in mm)	Length (in mm)	Breadth (in mm)	appearance
48 hrs	11	3	9	7	small
72 hrs	18	5	12	9	small
96 hrs	24	8	17	12	medium
5th day	34	10	26	15	Medium-large

Table 6. Seedling characters observed after treatment (treated) with musical notes in lima bean *(Phaseolus lunata*)

Day	Radicle	Plumule	Cotyledon leaves		
	Length (in mm)	Length (in mm)	Length (in mm)	Breadth (in mm)	appearance
48 hrs	19	5	13	12	small
72 hrs	30	7	17	15	small
96 hrs	36	14	23	19	medium
5th day	48	19	32	26	Medium-large

Table 7. Seedling characters observed without treatment (control) with musical notes in yellow pea (*Lathyrus aphaca*)

Day	Radicle	Plumule	Cotyledon leaves		
	Length (in mm)	Length (in mm)	Length (in mm)	Breadth (in mm)	appearance
48 hrs	20	14	15	13	small
72 hrs	22	17	18	16	small
96 hrs	28	21	24	21	medium
5th day	34	23	32	29	Medium

Table 8. Seedling characters observed after treatment (treated) with musical notes in yellow pea (*Lathyrus aphaca*)

Day	Radicle	Plumule	Cotyledon leaves		
	Length (in mm)	Length (in mm)	Length (in mm)	Breadth (in mm)	appearance
48 hrs	24	17	17	14	small
72 hrs	27	22	20	18	small
96 hrs	31	25	26	23	medium
5th day	38	28	36	30	large

6.Conclusion

It might have happened by the application of single tone frequency of Flute, the absorption of water and moisture was increased, which in turn influences metabolic rates. When this was followed by the application of harmonic frequency of stringed musical instruments santoor and sitar causing a greater number of frequency and increased resonance, which might have also affected the absorption of water followed by increased metabolic activities and increased enzyme activities causing an enhancement of respiration rates, occurring during seed germination. One result from a research report has proved that audible sound treatment can promote the growth of mung bean (*Vigna radiata)* differently for distinct frequency and intensity of music (Cai, et al. 2014). The level of polyamines, the uptake of oxygen (Qin et al. 2003), the regulation of antioxidant enzymes (Li et al. 2008), the synthesis of RNA and soluble proteins (Wang et al. 2003), and perhaps most importantly, gene expression level were enhanced on exposing the seedlings and mature plants to green music or classical music and natural sounds such as those of birds, insects, water, etc., as compared to the controls, however to established the detailed mechanism work is going on.

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8. References

1. Burridge R., Kappraff J., Morschedi C. 1982. The sitar string: a vibrating string with one-sided inelastic constraint. SIAM J Appl Math. 42:1231-1251.

2. Cai W., He H., Zhu S., Wang N. 2014. Biological Effect of Audible Sound Control on Mung Bean (*Vigna radiata*) Sprout. BioMed Res. Int. 6:1-7.

3. Chivukula V., RamaswamyS. 2014. Effect of different types of music on *Rosa chinensis* plants. Int. J. of Environ Sci Te. 5:1-4.

4. Chundury P.R.K., Viswanathan G. 2015. Bio-assay of *Cicer arietinum* (Bengal gram), *Macrotyloma uniflorum* (Horse gram), *Vigna radiata* (green gram); exposed to vedic chanting-Lalitha Sahasranama compared with control. World J. Pharm Pharm Sci. 4:724-731.

5. Creath K., Schwartz G.E. 2004. Measuring effects of music, noise, and healing energy using a seed germination bioassay. J Altern Complem Med. 10:113-122.

6. Crowe B.J., Colwell C. 2007. Effective clinical practice in music therapy: Music therapy for children, adolescents, and adults with mental disorders. Silver Spring, MD: American Music Therapy Association. 175-200.

7. Ekici N., Dane F., Mamedorah L., Metin I., Huseyinov M. 2007. The effects of different musical elements on root growth and mitosis in onion (*Allium cepa*) root apical meristem (musical and biological experimental study). Asian J. Plant Sci. 6:369-373.

8. Gautama Reddy K.V., Ragavan G., Ragavan R. 2013. Classical Ragas: a new protein supplement in plants. Indian Journal of Life Sciences. 3:97-103.

9. Goldstein B.E. 1966. Sensation and perception. Brooks/Cole Publishing Co., pp. 1-464.

10. Hassanien R.H.E, Hou T.-Z., Li Y.-F., Li B.-M. 2014. Advances in effects of sound waves on plants. J. Integr. Agric. 13:1-23.

11. Joersbo M., Brunstedt J. 1992. Sonication a new method for gene transfer to plants. Physiol. Plant. 85:230-234.

12. Kneafsey R. 1997. The therapeutic use of music in a care of the elderly setting: a literature review. J. Clin. Nurs. 6:341-346.

13. Lapp D.R. 2002. The physics of music and musical instruments. Wright Center for Innovative Science Education. Tufts University, Medford, Massachusetts. 119 p.

14. Li B., Wei J.M., Wei X.L., Tang K., Liang Y.L., Shu K.X., Wang B. 2008. Effect of sound wave stress on antioxidant enzyme activities and lipid peroxidation of *Dendrobium candidum*. Colloids Surf. B. 63:269-275.

15. Moore G.D. 2006. Physics of music lecture notes. McGill University, Canada. 173 p.

16. Recek N., Holc M., Vesel A., Zaplotnik R., Gselman P., Mozetič M., Primc G. 2021. Germination of Phaseolus vulgaris L. seeds after a short treatment with a powerful RF plasma. International Journal of Molecular Sciences. 22:66-72.

17. Retallack D. 1973. The Sound of Music and Plants. Santa Monica, CA: DeVorss & Co. 96 p.

18. Rigden J.S. 1977. Physics and the sound of music. Wiley, New York. 71 p.

19. Sethares W.A. 1998. Tuning, timber, spectrum, scale. 2nd edition.Springer, London. 426 p.

20. Suslick K.S. 1989. Ultrasound: Its chemical, physical and biological effects. New York, VCH Publishers. 227 p.

21. Vanol D., Vaidya R. 2014. Effect of types of sound (music and noise) and varying frequency on growth of guar or cluster bean (*Cyamopsis tetragonoloba*) seed germination and growth of plants. Ashok & Rita Patel Institute of Integrated Study & Research in Biotechnology and Allied Sciences (ARIBAS). Quest. 2: 9-14.

22. Wang X., Wang B.C., Jia Y. 2003. Effect of Sound Wave on the Synthesis of Nucleic Acid and Protein in *Chrysanthemum*. Colloids Surf. B. 29: 99-102.

23. Wood A. 1976. The physics of music. Chapman and Hall, London. 258 p.