

Biological responses of Sri Lankan rice (*Oryza sativa* L.) varieties to rhythmic sound patterns (music and religious chants)

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Abstract. Munasinghe DSP, Weerakoon SR, Somaratne S. 2020. Biological responses of Sri Lankan rice (*Oryza sativa* L.) varieties to rhythmic sound patterns (music and religious chants). *Nusantara Bioscience* 12: 154-161. Influences of music cause either promoting or restricting the growth of plants. The effects of *Pirith* chanting and rhythmic sound patterns (Western classical music, Eastern classical music, Rock music) were focused in the present study. Seeds of Two (02) rice varieties (Bg 300 and *Kuruluthuda*) in f_0 and f_1 generations were subjected to dormancy break treatment, kept in a soundproof confined chamber, and arranged in Randomized Complete Block Design (RCBD) with two (02) replicates and 10 seeds per replicate. Seeds were germinated under the three sound rhythms, *Pirith* chanting, and silence. Plants kept under silence served as the control. Sound rhythms and *Pirith* were played separately for an hour, at 30 cm distance away from the seeds with an intensity of 55-60 dB for seven (07) days continuously, maintaining equal environmental conditions. Following seven (07) days, the percentile germination rate was recorded. Germinated seeds were planted in plastic pots filled with paddy soil, up to $\frac{3}{4}$ of the total depth, and pots were arranged in Randomized Complete Block Design (RCBD) with five (05) replicates and three (03) plants per replicate. Following one week, plants were subjected to sound rhythm treatments and silence for three (03) months continuously. Measurement of growth and yield performance were recorded every fortnight. Significantly different ($p < 0.05$) growth and yield performances in both generations were observed under *Pirith*, Eastern Classical and Western Classical music. Higher rates of growth were observed for rice varieties exposed to *Pirith*, Eastern and Western classical music. Similarly, yield was also higher compared to rice varieties exposed to rock music. The findings suggest that soft rhythmic sounds are the most appropriate type of music which improved growth and yield performance of rice varieties, Bg 300, and *Kuruluthuda*. However, further studies are needed to confirm present results and to elucidate the mechanism of responses to *Pirith* chanting and other rhythmic sound patterns using phytochemical and biochemical analyses.

Keywords: Eastern classical music, *Oryza sativa*, *Pirith*, rock music, Western classical music

INTRODUCTION

Plants are complex multicellular organisms considered as sensitive as humans for initial assaying of effects and testing new therapies (Dossey 2001). Sound has always been considered a fundamental part of life on earth and is known to affect the growth of plants and respond to music the same as humans do. Although most known species of animals are known to communicate with each other *via* sounds, the association of plants with sound production or recognition has hardly been discussed. However, mounting scientific evidence does appear to suggest that plants could be capable of recognizing and responding to sounds in nature and to sounds produced by human beings (Douglass et al. 1993).

Retallack and Broman (1973) the author of "The Sound of Music and Plants" attempted experimenting with different types of music, 'rock music' and "soothing music" such as classical and jazz music pieces of Beethoven, Bache, and Chopin. The plant group exposed to "rock" turned out to be sick and small whereas the other group grew large and healthy. After 2 weeks, plants physically leaned 15 to 20 degrees towards the radio playing classical and jazz music, while others struggle to grow away from "rock" music and eventually became malnourished. The

group of plants listening to the soothing music grew to bend towards the radio just as they bend towards the sunlight (Retallack and Broman 1973). As stated by Sanyal et al. 2013) did a number of experiments with classical Indian music, with amazing results, which eventually, stimulated harvests that were from 25-60% higher than average, and nearly 50% higher for peanuts and tobacco. Subsequently, experiments were done on many other plants and had proven that harmonic sound waves affect the growth, flowering, fruiting, and seed-yields of plants (Sanyal et al. 2013). Chowdhury and Gupta (2015) reported 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.

The effect of religious chanting on plant growth has been studied in many countries around the world including India, China, and Nepal. In India, mantras in Hindu Veda, such as Gayathri manta and Agnihotra mantra have been used to test plant growth performances. Mantras have shown that there was an overwhelming effect on seed

germination and growth on rice (Devi et al. 2004). Farmers in East China's Fujian Province have claimed that Buddhist chanting playing in the fields has helped to increase rice production. Output in Liangshan village in China went up by 15% after residents installed 500 lotus-shaped speakers in the rice paddies to engulf the crops in a wave of Buddhist chanting in rice fields also yielded larger grains, while the silent paddies with no music suffered from pests (www.bbc.com 2014). In Sri Lanka, the cultivation of rice goes back to many centuries and in ancient cultivation system, farmers had long believed and practiced chanting *Pirith* and sprinkling *Pirith*-chanted water to paddy fields when bearing (initiation of panicle) time arrives and believed that these religious practices would bring higher yield from the cultivation. An experiment conducted with two Sri Lankan rice varieties (Bg 300 and *Kaluheenati*) exposed to *Pirith* chanting for three months continuously implied that there was a positive influence on growth and yield performance of both rice varieties (Munasinghe et al. 2018).

Sound triggers drastic changes in plant metabolism. Plants are responding to sound and music and its wavelengths. Music containing uncompromising vibrations could be devastating to plant (Collins and Foreman 2001). There is no conclusive proof to describe that plants respond to sound. However, from the evidence gathered, scientists have proposed mechanisms by which these plants might hear and react to sound produced by other living creatures or inanimate objects, explaining that plants could do this by receiving sound sensations in the form of touch sensations similar to the way human heart thump when hearing a stereo playing at full blast. Similarly, plants respond to winds, perceiving it as a sensation of touch, plants could also respond to the sound which travels in waveform (Vanol and Vaidya 2014). Musical sounds could influence plant growth in different forms.

It has been reported that specific sound frequencies activate certain genes to increase the growth of plant cells. The resonance occurs at molecular levels when the frequencies of music and plant cells match. Jeong et al. (2008) identified a set of sound-responsive genes in rice using a sound-treated subtractive library and demonstrated sound regulation through mRNA expression analyses. Under both light and dark conditions, sound up-regulated expression of genes, *rbcS*, and *ald*. These are also light-responsive genes and these results suggest that sound could represent an alternative to light as a gene regulator. *Ald* mRNA expression increased significantly with treatment at 125 and 250 Hz, whereas levels decreased significantly with treatment at 50 Hz, indicating a frequency-specific response.

Sound affects stomata to stimulate in air exchange (Sharma et al. 2001). The music helps the stomata to remain wide open for an increased intake of foliage nutrients and water. The fluid moves more rapidly and is intensely stirred around resonating objects. Certain frequencies create resonance in the cell organelles of living organisms by increasing the movement of cytoplasm within the cells which leads to the growth of cells (Vanol and Vaidya 2014). Different vibrating patterns create a high or

low pitch. The plant cells feel the pressure of different vibrations and the variations and exposure time of which stimulate growth, diffusion, and stirring of liquid or air molecules in cells. The living organisms are composed of protoplasm, which constantly moves. The sounds vibrate the leaves and increase this movement which increases the growth of healthy plants by increasing the synthesis of food and nutrients. The loud warble sound doubled the growth of dwarf pea plants. The plant hormone called gibberellic acid responds to sound and causes shoot elongation or seed germination. The effect disappeared when its biosynthesis was stopped by chemicals (Collins and Foreman 2001).

If it is proved that plants listen and respond to different sound patterns, it would find wider practical applications in cultivation, forestry, and other cultivation related programs. There are reports in China that by broadcasting sound waves of certain frequencies, crops yielded higher. It is worthwhile carrying out studies to improve plant-yield and growth rates with the help of sound waves of varying frequencies. Healthier plants may also be able to develop with the help of music that the plants prefer. If farmers and gardeners know what type of music, if any, helps plants grow more quickly, stronger, or lusher, it could affect the efficacy of their farming techniques. There is a lack of documented evidence on the influence of sound on growth and yield performance of *Oryza sativa*, however, studies have conducted and had obtained contrasting results for different stimuli for plants (Chowdhury and Gupta 2015). Therefore, the objective of this study is to compare the biological responses of *O. sativa* under five-sound treatments, *Pirith* chanting, Western Classical music, Eastern Classical music, Rock music, and silence (control).

MATERIALS AND METHODS

Seed materials

Commonly cultivated short-term two rice varieties, *Kuruluthuda* (traditional variety) and Bg300 (inbred variety) were used in the study. These lines were maintained in a greenhouse at the Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka.

Evaluation of the effect of rhythmic sound patterns (Music and religious chants) on rice seed germination

Dormancy broken seeds were kept in soundproof chambers according to Randomized Complete Block Design (RCBD). A total of 20 seeds were used to examine the effect of each rhythmic sound patterns, with two replicates and 10 seeds per each replicate. Seeds were allowed to germinate under rock music (rock songs starts with C major) (maximum amplitude: 0.02 m), Eastern Classical music) (maximum amplitude: 4.8×10^{-3}) (interlude based on the Raag "Basanth" of composers, Ravi Shankar, Ustad Ali Khan and Bismillah Khan), Western Classical music (maximum amplitude: 8.6×10^{-3}) (of composers Beethoven, Bache, and Mozart), *Pirith* (maximum amplitude: 5.5×10^{-3}) (Thunsuthra – Karaneyameththa suthra, Rathana suthra, Mahamangala

suthra) and silence conditions (Figure 1). The seeds exposed to silence served as the control. Music and *Pirith* were played separately for an hour, 30 cm distance away from the seeds with an intensity 55 – 60 dB for seven (07) days continuously, maintaining equal environmental conditions (Vanol and Vaidya 2014). Seven (07) days later the percentile germination rate was calculated.

Evaluation of the effect of different rhythmic sound patterns (Music and religious chants) on growth and yield performance of rice in Parent generation (f_0)

The germinated seeds of the previous experiment were planted in plastic pots filled with paddy soil, up to $\frac{3}{4}$ of the total depth according to Randomized Complete Block Design (RCBD). A total of 15 plants were used to examine the effect of each rhythmic sound patterns, with five replicates and three plants per each replicate. One week after planting, sound treatment was initiated. The same procedure in germination experiment was followed for two months continuously, maintaining equal environmental conditions. Growth performance parameters such as plant height (from the ground to the tip of the tallest tiller of the plant), number of leaves, leaf length, number of tillers, dry weight and chlorophyll content using DMSO (Su et al. 2010), and yield performance such as number of days to initiation of panicle, number of panicles, spikelets, seeds, 1000 grain weight and filled grain percentage was recorded once in every two weeks. The concentrations of total

chlorophyll were calculated by the following equation (Zhang et al. 2009).

$$\text{Chl}_a \text{ (ug.g}^{-1}\text{)} = 12.72 \text{ OD}_{663} - 2.59 \text{ OD}_{645} \quad (1)$$

$$\text{Chl}_b \text{ (ug.g}^{-1}\text{)} = 22.9 \text{ OD}_{645} - 4.67 \text{ OD}_{663} \quad (2)$$

$$\text{Chl}_{\text{total}} \text{ (ug.g}^{-1}\text{)} = \text{Chl}_a + \text{Chl}_b = 20.31 \text{ OD}_{645} + 8.05 \text{ OD}_{663} \quad (3)$$

Fertilizer management and the other crop management practices were followed according to the recommendations of Department of Agriculture (agridept.gov.lk. 2014).

Evaluation of the effect of different rhythmic sound patterns (Music and religious chants) on growth and yield performance of rice up to 1st generation (f_1)

The same procedure explained in f_0 generation was applied for the self-pollinated 1st (f_1) generation of the two rice varieties exposed to different sound patterns in f_0 generation and growth and yield performance parameters were recorded once in every two weeks.

Data analysis

The collected data were analyzed with univariate and bivariate statistical using post hoc procedures. The analyses were carried out using SPSS statistical software (IBM, Version 23). In addition, data mining analysis was also attempted for the data gathered from the study to reduce the noise in the data set.

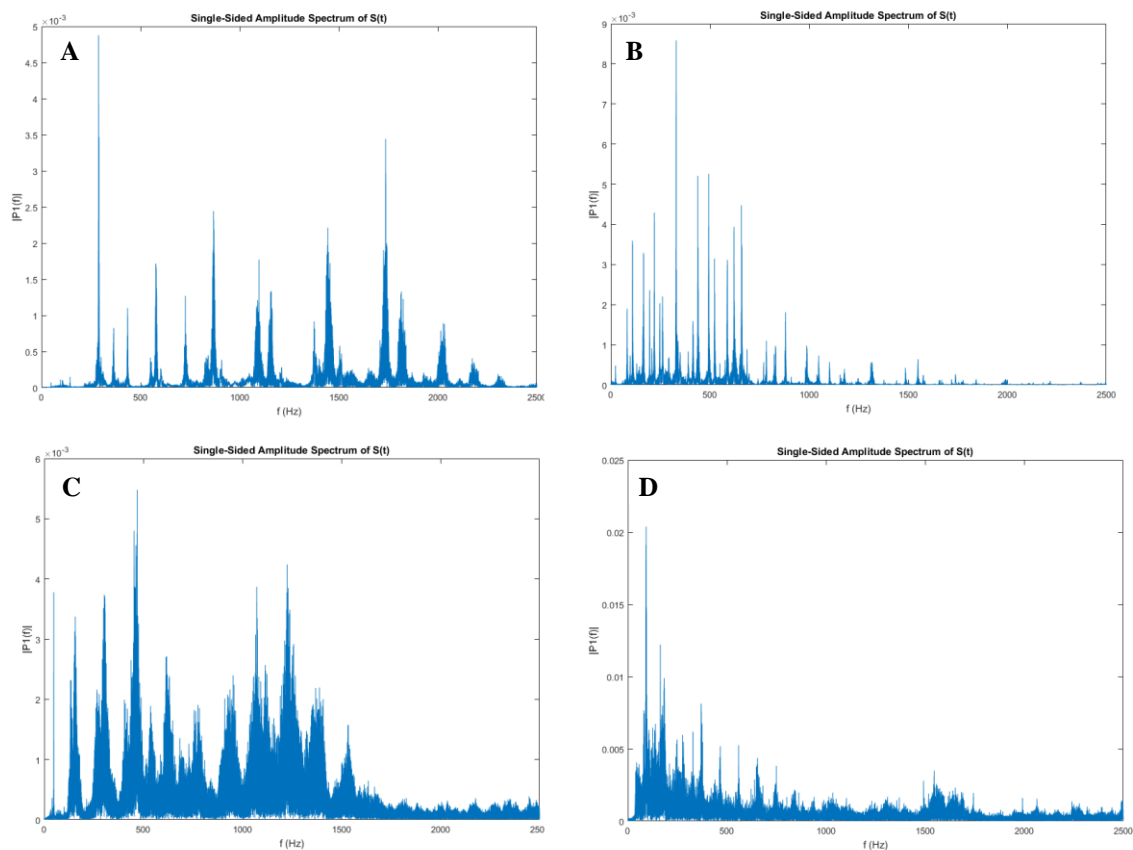


Figure 1. Amplitude variations of A. Eastern classical music, B. Western classical music C. *Pirith* chanting and D. Rock music

RESULTS AND DISCUSSION

Effect of rhythmic sound patterns (Music and *Pirith* chants) on rice seed germination

Tested rice varieties showed significant difference in the germination rate in parent (f_0) and first-generation (f_1) (Figure 2). Compared to the control treatment, parent generation of both varieties, *Kuruluthuda* and Bg300 indicated considerable increase in germination rate of 62% and 90% under Western classical music and 62% and 82% under Eastern classical music, respectively (Figure 2.A). The response of the same varieties under Rock music indicated the lowest germination percentage while *Pirith* was moderate in germination percentage for both rice varieties.

First-generation (f_1) of tested rice varieties showed more or less similar results as in the parent generation (Figure 2.B). Considerably lower germination percentage was observed for f_1 of *Kuruluthuda* for tested sound experiments except in *Pirith* (67%) bringing the highest germination percentage of the respective generation. However, Bg300 showed higher germination percentage compared to that of the parent generation (f_0) for tested sound treatments. Similar results were obtained as in the parent generation for Bg300, bringing the highest germination percentage for Western Classical (97%) and Indian Classical (90%). The response of the same varieties under Rock music indicated the lowest germination percentage.

Effect of different rhythmic sound patterns (Music and religious chants) on growth and yield performance of rice in parent generation (f_0)

The variations of plant height, leaf length, chlorophyll content, field-grown percentage, and dry weight of the parent generation were shown in Table 1 and Figure 3. Compared to control and Rock music, Eastern Classical music, Western Classical music, and *Pirith* showed significance in plant height, 1000 seed weight, filled grain %, and dry weight ($p < 0.05$). Among them, *Pirith* and Indian classical music have shown higher values for plant height and dry weight, and, 1000 seed weight and filled grain %, respectively (Table 1). Although, an apparent increase in the magnitude of chlorophyll content for *Pirith* and Indian Classical music was observed, there was no significant difference between other tested sound treatments (Table 1). Meanwhile, ANOVA performed in between groups of the parent generation showed marked significance in plant height ($p = 0.001$), 1000 seed weight ($p = 0.026$), field-grown % ($p = 0.001$) and dry weight ($p = 0.016$) (Table 2).

Chi-square test was performed on non-parametric data of the parent generation (Table 3). According to the results, marked significance was obtained for number of leaves ($p = 0.010$) and number of panicles ($p = 0.001$) per plant. Further, based on the results of Table 03, number of leaves and number of panicles per plant were analyzed, dividing the mentioned parameters into different classes (Leaf class 1= <7 , 2 = ≥ 7 to <9 and 3= ≥ 9 , Panicle class 1= <5 , 2 = ≥ 5 to <10 and 3 = ≥ 10). Cross-tabulation of the growth characteristic of number of leaves per plant (Leaf class 1= <7 , 2 = ≥ 7 to <9 and 3= ≥ 9) number of panicles per plant (Panicle class 1= <5 , 2 = ≥ 5 to <10 and 3 = ≥ 10) with respect to tested sound treatment indicated higher impact from Eastern classical music and *Pirith*, respectively (data not shown).

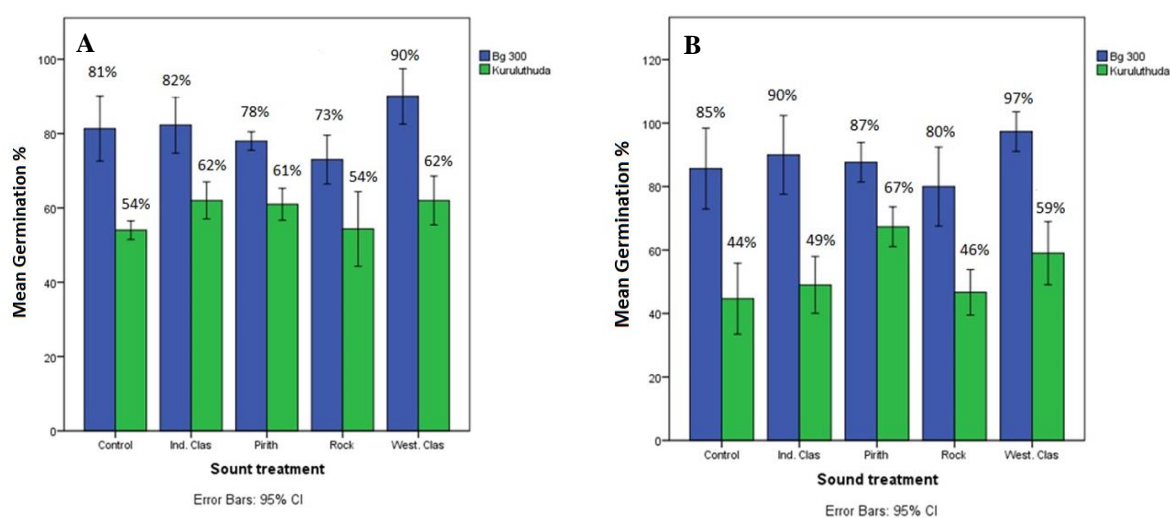


Figure 2. Germination percentage of: A. Parent generation (f_0) and B. First-generation (f_1) of *Kuruluthuda* and Bg 300

Table 1. Summary statistics of the parameters measures across different treatments of the parent generation

Sound treatment	Plant height (cm)	Chlorophyll content	1000 seed weight(g)	Filled grain %	Dry weight (g)
Control	96.50 (3.61)b	24.83 (1.16)a	19.33 (1.03)d	31.00 (2.75)d	2.80 (0.22)c
Eastern classical	99.50 (3.56)a	25.50 (1.51)a	22.00 (1.26)a	37.67 (4.84)a	2.96 (0.56)b
Pirith	100.00 (2.19)a	25.50 (1.37)a	20.50 (1.64)c	35.50 (4.03)b	3.58 (0.30)a
Rock music	92.17 (2.48)c	23.17 (2.63)a	19.33 (1.75)d	26.00 (6.09)e	2.96 (0.43)b
Western classical	97.00 (2.00)b	24.67 (1.50)a	21.67 (2.42)b	32.17 (3.71)c	2.73 (0.50)c

Note: The mean values are followed standard deviation within parenthesis. The same letter along the columns indicates no statistically significant difference at $p \leq 0.05$.

Table 2. Analysis of variance (ANOVA) in between groups of the parent generation

	Sums of square	df	Mean square	F	Sig.
Plant height x Sound treatment	233.133	4	58.283	7.148	0.001
Chlorophyll x Sound treatment	21.867	4	5.467	1.847	0.151
1000-seed weight.x Sound treatment	37.867	4	9.467	3.310	0.026
Filled grain x Sound treatment	481.800	4	120.450	6.125	0.001
Dry weight. x Sound treatment	2.719	4	.680	3.752	0.016

Note: The mean values are followed standard deviation within parenthesis. The same letter along the columns indicates no statistically significant difference at $p \leq 0.05$.

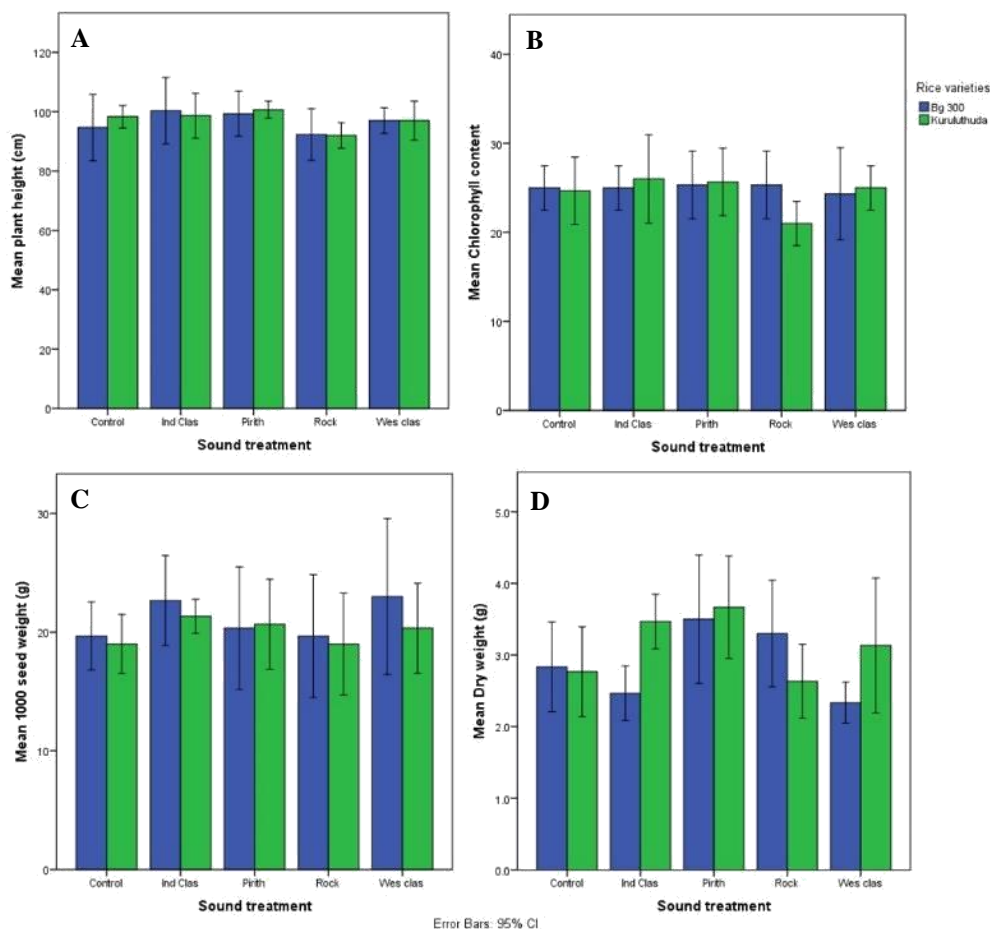
**Figure 3.** Effect of sound treatments on: A. Mean plant height, B. Mean chlorophyll content, C. Mean 1000 grain weight, and D. Dry weight (g) of the parent generation

Table 3. Chi-square value of non-parametric data of the parent generation

	Pearson Chi-Square value	df	Asymp. Sig (2-sided)
Number of leaves	20.168	4	0.010
Number of tillers	2.222	4	0.695
Number of panicles	18.462	4	0.001
Number of spikelets	4.880	4	0.300
Number of seeds	5.000	4	0.287

Note: $\chi^2=20.168$, $d=8$, $P \leq 0.05$

Effect of different rhythmic sound patterns (Music and religious chants) on growth and yield performance of rice in first-generation (F₁)

The summary statistics of parametric data of the first generation were shown in Table 4 and Figure 4. Compared to the parent generation, highlighted results were obtained for the first generation. Among the tested sound treatments,

Pirith scored the highest values in filled grain % and dry weight (Table 4). Similarly, Western classical music and Eastern classical music showed higher values for plant height and chlorophyll content. Rock music in both generations had the least effect on tested rice cultivars. ANOVA of the first generation data indicated that only plant height ($p = 0.004$), chlorophyll content ($p = 0.001$) and filled grain % ($p = 0.050$) showed marked significance with respect to sound treatment (Table 5).

Chi-square test was performed on non-parametric data of the first generation (Table 06). Unlike in parent generation, marked significance was obtained only for number of panicles ($p = 0.024$) per plant in the first generation. Based on the results of Table 05, *Pirith* and Eastern Classical music indicated higher impact on number of panicles per plant when dividing the mentioned parameter to different classes (Panicle class 1 = <5, 2 = ≥ 5 to < 10 and 3 = ≥ 10) (data not shown).

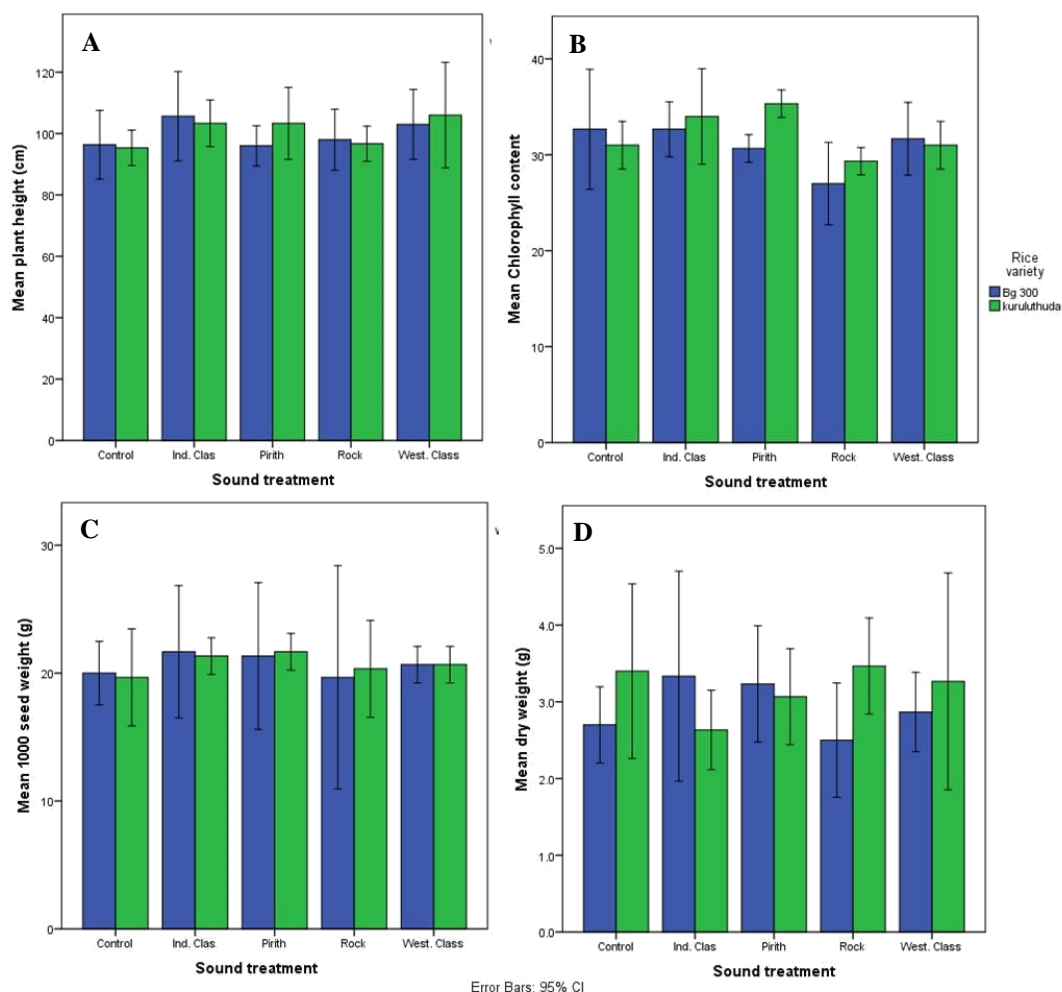


Figure 4. Effect of sound treatments on: A. Mean plant height, B. Mean chlorophyll content, C. Mean 1000g grain weight, and D. Dry weight (g) of the first generation

Table 4. Summary statistics of the parameters measures across different treatments of the first generation

Sound treatment	Plant height (cm)	Chlorophyll content	1000g grain weight (g)	Filled grain (%)	Dry weight (g)
Control	95.83 (3.25) ^c	31.83 (1.94) ^b	19.83 (1.16) ^a	33.33 (7.63) ^b	3.05 (0.49) ^a
Eastern classical	104.50(4.37) ^a	33.33 (1.63) ^a	21.50 (1.37) ^a	37.67 (7.9) ^c	2.98 (0.53) ^b
Pirith	99.67 (5.27) ^b	33.00 (2.60) ^a	21.50 (1.51) ^a	41.00 (6.84) ^d	3.150 (0.26) ^a
Rock music	97.33 (3.01) ^c	28.17 (1.72) ^c	20.00 (2.44) ^a	26.17 (6.52) ^a	2.98 (0.58) ^b
Western classical	104.50 (5.50) ^a	31.33 (1.21) ^b	20.67 (0.51) ^a	35.67 (11.75) ^c	3.06 (0.44) ^a

Note: The mean values are followed standard deviation within parenthesis. The same letter along the columns indicates no statistically significant difference at $p \leq 0.05$

Table 5. Results of Analysis of variance (ANOVA) of the first generation

	Sums of square	df	Mean square	F	Sig.
Plant height x Sound t.	286.467	4	96.617	4.985	0.004
Chloro. x Sound t	101.133	4	25.283	7.156	0.001
1000-seed weight. x Sound t.	15.133	4	3.783	1.599	0.206
Filled g x Sound t.	744.533	4	186.133	2.676	0.050
Dry weight. x Sound t.	0.115	4	0.029	0.126	0.972

Note: The mean values are followed standard deviation within parenthesis. The same letter along the columns indicates no statistically significant difference at $p \leq 0.05$.

Table 6. Chi-square value of non-parametric of the first generation

	Pearson Chi-Square value	df	Asymp. Sig. (2-sided)
Number of leaves	4.800 ^a	4	0.308
Number of tillers	6.244 ^a	4	0.182
Number of panicles	11.250 ^a	4	0.024
Number of spikelets	3.880 ^a	4	0.340
Number of seeds	5.210 ^a	4	0.287

Note: $\chi^2 = 20.168$, $d = 8$, $P \leq 0.05$

Discussion

A study conducted on the effect of music with low frequencies on germination rate of two rice varieties revealed that music with low frequencies facilitates increased germination rate (Creath and Schwartz 2004) and the soft rhythm of music and sounds causes plants to grow healthier (Chowdhury and Gupta 2015). In the present experiment, rice plants in both generations experienced soft rhythmic sounds through *Pirith* chanting, Eastern and Western Classical music, which had comparatively lower amplitude, having a significant difference in most of the parameters recorded for two rice varieties. These results supported the hypothesis by Chowdhury and Gupta (2015). According to Wang et al. (2003) germination index, height of stem, relative increase rate of fresh weight, activity of root system, and the penetrability of cell membranes were significantly increased when rice plants subjected to different music fragments. These findings support the results obtained from the present study. Chowdhury and Gupta (2015) further describe in their hypothesis that the increment of growth rate of plants was attributed to

increase in the production of proteins when appropriate tune is played. Thus, the metabolism of the plant is increased. In the present study, the hospitable environment for the increment of growth and yield performance of rice plants in both generations would have facilitated through *Pirith* chanting, Eastern and Western Classical music rather than Rock music., outstandingly *Pirith* chanting becoming the appropriate tune. Collins and Foreman (2001) obtained the same results for the increment of plant height and yield of beans and impatiens.

Harsh music had negative effect on plant growth and yield performance (O'Donnell 1999). In the present study, growth and yield parameters were declined in Rock music compared to *Pirith* and silence conditions in both generations. The declined in dry weight, 1000-seeds weight, and filled grain % indicated that pop music had negatively affected the plant growth performances. Thus, plants under Rock music experienced a harsh environment condition for its growth and yield performance.

Comparatively, effect rhythmic sound patterns on *O. sativa* has caused a significant effect on their growth and yield parameters in first generation. By comparison, it was observed that Eastern classical music has helped in increase the plant height and chlorophyll content, *Pirith* for chlorophyll content, 100 seed weight and filled grain %, and Western classical music for plant height, chlorophyll content, filled grain % and dry weight. It is noteworthy that for Rock music, comparatively higher number of yield can be observed despite its severe effect on plant growth. The observed results indicate that *O. sativa* plants were well adapted to rhythmic sound patterns and of any kind the effect caused by these music waves might have altered genetic makeup of *O. sativa*. Studies have conducted to investigate the effect of music patterns and sound waves on

plant gene alteration. Xiujuan et al. (2003) showed that there was no obvious influence on the content of DNA of *Chrysanthemum* but accelerated the synthesis of RNA and soluble protein, implying that some stress-induced genes might be switched on under sound stimulation and the level of transcription increased. However, there is a limited number of reports available on the effect of *Pirith* and sermon chanting and different music patterns on plants including rice, the effect of rhythmic sound patterns on gene regulation, and successive generation.

In conclusion, *Pirith* chanting, Western Classical and Eastern Classical music positively influenced growth and yield performance in two (Bg300 and *Kuruluthuda*) rice varieties in this study. Further studies are needed to confirm these results and to elucidate the mechanism of responses to *Pirith* chanting and other rhythmic sound patterns in rice using phytochemical and biochemical analyses.

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