International Journal of Applied Agricultural Research
ISSN 0973-2683 Volume 5 Number 2 (2010) pp. 275–282

http://www.ripublication.com/ijaar.htm

The Influence of Sounds of Stringed Instruments on Growth of Medicinal Plant *Trigonella Foenum Graecum* (Family Fabaceae)

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Abstract

Trigonella foenum graecum herb has wide applications in medicine. In the present work, the effect of sounds produced by stringed instruments on the growth of *Trigonella foenum graecum* is studied. *Trigonella foenum graecum* seeds were thinly sown in the shallow drills made in the loam soil in the clay-pots. The pots were kept in an isolated place and in a dry atmosphere and at a constant temperature 20 ºC. All the pots were covered with glass boxes. One set of plants was exposed to recorded sounds of violin at frequency 1500 Hz and intensity level 50 dB while another set of plants to recorded sounds of Veena. The control was not exposed to any kind of sound. The growth parameters of the plants were recorded and after 28 days the plants were harvested and biochemical analysis was done. The plants responded significantly to the sounds of stringed instruments in terms of growth parameters. The plants were found to be uniform in size, lush green and healthier as compared to the untreated control. The plants showed positive sonotropic movement towards the source of music. Bio chemical analysis showed that the amount of chlorophyll A, chlorophyll B, Carotinoides, carbohydrates and protein was also found to be increased in the plants exposed to sounds of stringed instruments. Since *Trigonella foenum-graecum* has high medicinal value the mass production of good quality *Trigonella foenum graecum* plants, plants can be exposed to the sounds of stringed instruments at frequency 1500 Hz and 50 dB intensity level.

Keywords: sound frequency, stringed instruments, intensity level, *Trigonella foenum graecum* , growth-rate, biochemical assay.

Introduction

The seeds of *Trigonella foenum graecum* (fenugreek) are reported to have restorative and nutritive properties.[1] It is traditionally used to treat disorders such as diabetes, high cholesterol, wounds, inflammation, and gastrointestinal ailments.[2] Plants are complex multicellular organisms considered as sensitive as humans. Sound is known to affect the growth of plants.[3] The effect of sound stimulation on the metabolism of chrysanthemum roots was studied and it was found that the growth of roots was not inhibited but accelerated under suitable sound stimulation.[4] The seeds and leaves of fenugreek are edible and are used as condiments and as Ayurvedic medicine in the Indian subcontinent.[5] Fenugreek seeds have been successfully tested in laboratory animals and in humans with type 1 and type 2 diabetes as a hypoglycemic agent.[6][7][8] It was also found that fenugreek seeds can modulate several enzymes, including those associated with glucose and lipid metabolism.[9] Extracts of fenugreek seeds and some of their saponin constituents have been found to have anticarcinogenic potency in different settings.[10][11]

Sound is a form of energy and is known to affect the growth of plants. Seeds are sometimes treated with ultrasound to help start the germination process. Foliage planted along freeways to reduce noise pollution often grows differently than foliage planted in a quiet environment. Sound vibration can stimulate a seed or plant. [12] Studies in the audible frequency range have examined effects on seed germination. Experiments were focused on single frequency in an attempt to map responses as a function of frequency. Several studies on plants using music and/or noise have been conducted.[13][14][15][16][17] but it was difficult to replicate because the precise experimental conditions were not specified. Also the growth of plants depends upon the frequency of the sound and how the sound is being produced. Since *Trigonella foenum graecum* is a plant with high medicinal value, good quality *Trigonella foenum graecum* plants need to be produced in large quantities. In present research work the effect of sounds of constant frequency 1500 Hz and at 50 dB intensity level produced by stringed instruments Violin and Veena are studied on the growth rate of medicinal plant *Trigonella foenum-graecum.* In stringed instruments, the strings are the most important part since the strings generate periodic vibrations in the sound. They are designed to vibrate the air around them and propagate pressure waves. In the present work, this change in pressure is found to affect the rate of photosynthesis and in turn plant growth. Sounds of stringed instruments were found to exert additional pressure which resulted in better growth of plants.

Materials Used

- Selected *Trigonella foenum-graecum* seeds soaked overnight in distilled water.
- CD's containing recorded sounds of Violin and Veena at frequency 1500 Hz.
- CD player with 2 small speakers.
- 3 Glass boxes to cover the plants to make it sound-proof.

- Three clay- pots containing three compartments each of 8 inches in breadth and 6 inches height.
- Temperature controlling unit.

Methodology

The good quality seeds were selected and soaked in distilled water for 24 hours in the darkness and at room temperature. The little sprouts were seen after soaking for 24 hours. The sprouts were rinsed again and drained and left to air dry for 24 hours. Three clay pots with three compartments of breadth 8 inches and height 6 inches were taken. Selected 33 *Trigonella foenum-graecum* seeds were sown in the shallow drills made in the loam soil separately in each compartment of each clay pot. Thus each clay pot consisted of 99 seeds of fenugreek. Then all the three pots labeled as T1, T2 and T3 respectively, were kept in a sunny position and in a dry atmosphere. A temperature controller unit was kept beside each pot to maintain a constant temperature of 20ºC. Two small speakers were kept near the pots T2 and T3 and then all the three pots were covered with the glass boxes with a small hole to prevent from extraneous sounds. All the plants were watered in the morning and evening regularly. The recorded violin sound of frequency 1500 Hz and loudness level 50 decibel was played to the seeds sown in the pot T2 and recorded Veena sound of frequency 1500

Hz loudness level 50 decibel was played to the seeds sown in the pot T3 every morning and evening at the same time for one hour. The pot labeled T1 was treated as control and no sound was played to it. The rate of growth of the plants was recorded and after 28 days plants were harvested and biochemical analysis was done and the results were compared with the control.

Table 1: Effect of sounds of stringed instruments on plant height and number of leaves of T. foenum-graecum plants.

	Stem height(cm)				No. of leaves			
No of days	7	14	21	28	7	14	21	28
T1	1.92	2.21	3.43	4.21	1.51	1.62	2.45	3.21
T2	3.22	5.65	8.32	10.4	1.91	2.31	4.68	6.80
T3	2.34	3.45	5.33	7.36	1.56	1.78	2.68	4.54

The values shown in the above table are the average values taken for all the 99 plants in each clay pot.

Table 2: Effect of sounds of stringed instruments on the circumference of the stem at the top and at the base, leaf area of *T. foenum-graecum* plants.

Treatment	**Circumference of the stem at the top (cm)**				**Circumference of the stem at the base (cm)**			
No of days	7	14	21	28	7	14	21	28
T1	0.18	0.22	0.29	0.32	0.07	0.15	0.26	0.33
T2	0.29	0.62	1.22	1.61	0.41	0.75	1.54	2.09
T3	0.21	0.31	0.81	1.01	0.25	0.42	0.94	1.32

The values shown in the above table are the average values taken for all the 99 plants in each clay pot.

Table 3: Effect of sounds of stringed instruments on the leaf area of *T. foenum-graecum* plants.

Treatment	**Leaf area (cm^2)**			
No of days	7	14	21	28
T1	0.98	1.05	1.68	2.13
T2	1.18	2.25	3.24	5.16
T3	1.08	1.43	2.12	3.21

The values shown in the above table are the average values taken for all the 99 plants in each clay pot.

Table 4: Biochemical Analysis.

	Control T1	**Violin T2**	**Veena T3**
Chlorophyll A (mg/ml)	11.27	12.94	12.12
Chlorophyll B (mg/ml)	3.85	3.90	3.5
Carotinoides (mg/ml)	4.68	5.21	4.90
Carbohydrates (mg/g)	50.0	52.0	51.0
Protein (mg/ml)	0.44	0.65	0.55

Results

It was observed that *Trigonella foenum-graecum* plants responded significantly to the sounds of string instruments in terms of growth parameters and biochemical assay when compared to an untreated control. The plants showed positive sonotropic movement towards the source of music. This movement was observed more when sounds of violin were played. The plants exposed to the sounds of stringed instruments were found to be uniform in size, lush green and healthier as compared to the control. Biochemical analysis of the plants also enables us to detect the effect of sounds of stringed instruments on plants. The amount of chlorophyll A, chlorophyll B, Carotinoides, carbohydrates and protein was also found to be increased in the plants exposed to the sounds of stringed instruments. Thus for the mass production of good quality medicinal plants, plants can be exposed to the sounds of stringed instruments.

Discussion

Sound is defined as the mechanical energy in the form of pressure variance in an elastic medium. The medium is air for voice and musical instruments. These variations are compressions and rarefactions in quick succession. The compressions are regions of high air pressure while the rarefactions are regions of low air pressure.

It is essentially a sort of wave of vibration that disturbs still matter. When sounds of stringed instruments are played, it forces surrounding air molecules to be compressed and expanded, creating a pressure disturbance consisting of an alternating pattern of compressions and rarefactions. The disturbance then travels from particle to particle through the medium, transporting energy as it moves. The amount of energy which is transferred to the medium is dependent upon the amplitude of vibrations of the string of the instrument. If more energy is put into the plucking of the string, then the string vibrates with greater amplitude. The greater amplitude of vibration of the string of the instrument thus imparts more energy to the medium, causing air particles to bedisplaced a greater distance from their rest position.[18] Subsequently, the amplitude of vibration of the particles of the medium is increased, corresponding to an increased amount of energy being carried by the particles. Sounds played by different instruments are different due to different overtones present in the sound. Overtones are the other frequencies besides the fundamental that exist in musical instruments. The overtones combine to form the characteristic sound of the instrument. In this experiment, both the sounds produced by Violin and Veena were of the same frequency , and therefore the same note. But their overtones are different, and therefore their sounds were different. The Violin’s jagged waveform produces a sharper sound, while the smooth waveform of the Veena produces a purer sound, closer to a sine wave. While both the instruments Violin and Veena use the same principles to produce sound, the way they are constructed and the materials used changes the overtones. In all stringed instruments, the strings are fixed at both ends, and are plucked or bowed to produce a standing wave. The velocity of a wave traveling in a vibrating string, and the tension of the string is related by the equation:

v = λf, and
v = [T / (m/L)]^½
where T is the tension in newton, m is the mass of the string, and L is the length of the string,
therefore
[T / (m/L)]^½ = λf
Therefore
f = {[T / (m/L)]^½} / λ

This frequency is known as the fundamental frequency. The reason that many stringed instruments sound so different is because the design of the body of the instrument resonates with different frequencies. The bridge and body of the violin, serve to transmit some of the vibrational energy of the string into the air as sound. Veena is a stringed instrument. It consists of a large body hollowed out of a block of wood. The stem of the instrument is also made of wood. The bridge is placed on the flat top of the body of the veena and the neck attached to the stem is usually carved into weird figure like the head of the A gourd which is smaller than the rounded part of the body is fixed underneath the neck. Twenty one metallic frets are fixed on the stem by means of a resinous substance. The Veena has seven strings. Of them four are main strings that pass over the frets and are attached to the pegs of the neck. The other strings are used as side strings for rhythmic accompaniment. Plants interact with their outside world through epidermal cells. The gases are exchanged through gaps in these cells which contract and expand like pores. There is also a collection of cells within these barriers that form a bulk of the leaf. These house chloroplast and perform the main chemical functions of plants. Every disturbance , whether its sound, light gravity or magnetism , is on a microscopic level a physical disturbance in the natural air. Sound is in the form of physical waves that has the potential to crash into the plant cells and damage them if the frequency and intensity level go beyond a definite level. This frequency and intensity threshold depends on the nature of the plant. As each cell is blasted with waves of sound or light, it alters the amount of RNA created which may Lead to increased or decreased growth rate. [19]The plants growth is accelerated when exposed to a comfortable frequency and intensity level as observed in the present research work. The sounds of given frequency and intensity level cause an extra pressure in the medium in which plant is kept. The pressure exerted on the plant affects the process of osmosis in the plant. A research study on plants proved that the osmotic pressure of the cell sap of agricultural crops has to be in a definite range of pressure .The amount of pressure affects the growth of plants.[20] When sound is played to the plants it produces additional pressure in the air around the plant in which it is kept. As the plants are covered with a glass box , the additional pressure can be easily calculated on the plants by the air enclosed within the box. Thus plants experience pressure (p_{total}) which is the sum of local ambient atmospheric pressure ($p_{0)}$ and pressure exerted by sound waves (p).

The entire pressure p_{total} is
$P_{total} = p_0 + p$ where
p_0 = local ambient atmospheric (air) pressure,
p = sound pressure deviation.

In present research work the additional pressure exerted by the sound of 1500 Hz frequency and intensity level 50 dB as produced by violin and was measured to be 0.006324555 Pa and 0.004424329 Pa respectively which accelerated the growth of *foenum graecum* plants. Thus for the large scale production of *foenum graecum* plants, which find wide applications in medicine, plants can be exposed to the sounds of stringed instruments of 1500 Hz and 50 dB intensity level.

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