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The Effects of Different Musical Elements on Root Growth and Mitosis in Onion (*Allium cepa*) Root Apical Meristem (Musical and Biological Experimental Study)

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Abstract: In this study effects of strong, complex, rhythmic accent classical music with sekunda and kvarta intervals and frequently reprized and opus with rhythmic dynamically changing lyrics which contain more extensive kvinta septa oktava intervals on mitotic index and root growth were investigated in onion (*Allium cepa*) root tip cells during germination. For this aim, music samples from Wagner, Mozart, Musorgsky, (Boris Godunov) Chopin, Tchaikovski, Schubert were chosen. We found correlation between root elongation and Mitotic Index (MI). Both kinds of music have positive effects on root growth and mitotic divisions in onion root tip cells but rhythmic dynamically changing lyrics affected much better. In this study light microscopy techniques were used but ultrastructure of root tip cells will be studied with electron microscope in the following study.

Key words: *Allium cepa*, music, effect, mitotic index, root elongation

INTRODUCTION

The use of music and sound to improve health is not a novel idea. Both harmful and beneficial effects of music have been recognized by the ancient Greeks and Romans, including Pythagoras, Democritus, Aristotle, Galen and Celsus (Rooke, 1985). Music is used in treatment of illnesses since for a long time past in China, India and Turkey. The effects of music treatment are better in neuropathies and depressions (Wicke, 2002).

In recently years, two terms are used for classifying music. These are positive and negative. Positive music can be described as music that has beneficial qualities and is emotionally and spiritually uplifting, perhaps even healing. Additionally, positive music can be relaxing, calming and mentally invigorating and negative music is music that stimulates the negative emotions: anger, frustration, depression, hatred and fear. It is the music that accompanies crime programs and horror films (Robertson, 1998).

Many people remember hearing in the 1950's about the idea that plants respond to music. Many experiments have been done to see what music's effect on growing plants is. There were lots of projects in high schools and

colleges which successfully tested the effects of sound on plant growth. Does music induce or reduce plants growth? Many studies have been done about this interesting subject.

In the 1950's, Indian botanist T.C. Singh made first recorded studies about effects of music on plants (Tompkins and Bird, 1989), about the same time, a Canadian named Eugene Canby began subjecting test plots of wheat to recordings of violin sonatas by J.S. Bach and found that yields increased by 66%. Other tests in Russia, the U.S. and Canada with ultrasonic frequencies yielded similar increases in the growth rates of other plant species (Robertson, 1998). Retallack (1973) determined that these frequencies were best administered in the form of classical music (compositions of J.S. Bach, Haydn, Beethoven, Brahms, Schubert and other European 18th and 19th century composers; traditional North Indian music performed on sitar and tabla), played intermittently for several hours per day.

Studies about effects of music were continued with Paddy (Subramanian *et al.*, 1969), wheat (Weinberger and Measures, 1979), Purple Passion vine plants (Tompkins and Bird, 1989) *Arabidopsis* (Braam and Davis, 1990), *Mimosa pudica* (Jones, 1991), Groovy plants (Davis and Scott, 2000), corn (Talos, 2001).

French physicist and musician, Joel Sternheimer, discovered the mechanism for how plants respond to the stimulation of sound waves. Sternheimer composes musical note sequences which help plants grow and has applied for an international patent covering the concept. The patent includes melodies for cytochrome oxidase and cytochrome C which are two proteins involved in respiration (Begich and Begich Slade, 2005-2006).

The aim of the present study is to investigate if the effects of strong, complex, rhythmic accent classical music with sekunda and kvarta intervals, frequently reprized and opus with rhythmic dynamically changing lyrics which contain more extensive kvinta septa oktava intervals on mitotic index and root growth were investigated in onion (*Allium cepa*) root tip cells during germination.

MATERIALS AND METHODS

All experiments were performed on adventitious roots of the onion *Allium cepa* on June 2006 in Edirne-TURKEY. The onion used in the experiment had been prepared as described by Wierzbicka (1987). They were placed in 60 mL tap water and grown in opaque containers at 22°C. pH values of water were performed with an Orion 720A Model pH meter using a combined electrode. Group 1 listened strong, complex, rhythmic accent classical music with sekunda and kvarta intervals, frequently reprized from Wagner (Venizberg scene), Musorgsky, Boris Godunov (different national anthems) and Group 2 listened opus with rhythmic dynamically changing lyrics which contain more extensive kvinta septa oktava intervals from Mozart (Re minor piano concerto), Chopin (waltzes), Tchaikovski (Seasons), Schubert (Ave Maria) were chosen. Onions listened music for 10 days, 6 h per a day. Sound intensity of musics were measured with sound label meter; Casella (2000).

The root elongation toxicity test was performed according to Chang *et al.* (1997). At the end of 10 days the total root length was measured. The experiment was set up in a completely randomized design with 4 replications. The significant difference between the treated and the control samples was analyzed by Student's-test. The values of root are means of 20 measurements.

After 10 days treatment, the root tips of onions were fixed in Carnoy fixative (3 alcohol: 1 acetic acid) and hydrolyzed in 1 N HCl at 50°C for 5 min followed by squashing in a 2% aceto orcein stain. Slides were kept in a freezer and examined within a month. Two thousand and five hundred cells were counted from each group and

mitotic index was determined according to equation below (Rojas *et al.* 1993). The slides were examined with an Olympus photomicroscope.

$$MI = M \times 100 / T$$

(MI: mitotic index, M: number of cells in metaphase, T: totally counted cell number)

RESULTS

The results of this study was evaluated in two steps; the effect of strong, complex, rhythmic accent classical music with sekunda and kvarta intervals, frequently reprized and opus with rhythmic dynamically changing lyrics which contain more extensive kvinta septa oktava intervals on root growth; on mitotic index. Also pH value of water was measured and found 7.58. Sound intensity levels of Groups 1, 2 and control are listened below (Table 1).

Phytotoxic effect (root elongation): Table 2 shows the positive effects of samples of strong, complex, rhythmic accent classical music and lyrics which contain more extensive kvinta septa oktava intervals music on the development of the onion roots. General toxicity can't be determined from the table. The phytotoxic effects (EC₅₀) of music for root elongation were not found at these kinds of music. We saw that after 10th day the development of the onion roots in water. There was positive change in the length of the adventive roots as we compared them with the control. But onions those exposed to lyrics were shown better growth and (Table 2 and Fig. 1).

Mitotic index: The effects of samples of strong, complex, rhythmic accent classical music and lyrics which contain more extensive kvinta septa oktava intervals music on mitotic frequency are shown in Table 2. All the samples of music water have positive effects on mitosis. The increase of mitotic frequency varies among music types (Table 2).

Table 1: Sound intensity levels of music those were listened by Groups 1 and Group 2

Group No.	L _{AF} max (dB)	L _{AF} min (dB)
1	74.6	40.0
2	64.7	--
Control	--	--

Table 2: Root elongation of *Allium cepa* and Mitotic Index (MI) in root meristematic cells of *Allium cepa* in Control group, Goup 1 and 2

Groups	Root elongation	Mitotic index (MI)
Group-1	9.54±1.9	7.8
Group-2	10.01±0.5	9.6
Control group	5.77±2.3	3.2



Fig. 1: *Allium cepa* roots of Control group, Group 1 and 2

DISCUSSION

Music, more than entertainment, has played an instrumental role in healing and harmonizing the mind, body and spirit. For thousands of years, the Vedic, China, India, Turkey and Greece culture has used sound and music for body and mind balancing, health enhancement, healing promotion and encouragement of heightened awareness. The Greek mathematician, Pythagoras theorized that music diminished and even eradicated negative energy and emotions (Bailey-Lloyd, 2003-2004). Bulgarian psychologist George Lozanov found that playing Baroque instrumental music (such as that of Handel and J.S. Bach) in the background while teaching foreign language vocabulary greatly increased student's speed of learning and degree of memory retention (O'Donnell, 1999).

In recently years music separated into two groups as positive and negative music. Relaxing, calming and mentally invigorating music is called as positive music. Positive music can be found in all cultures and all times. Negative music is used to create emotions of suspense, terror, anxiety and fear. It is the music that accompanies crime programs and horror films. This kind of music is created by a Viennese classical composer named Arnold Schönberg early in the 20th century first (Robertson, 1998).

Science is now showing that these sounds actually do influence the growth of plants. Researchers have demonstrated that plants respond to sounds in profound ways which not only influence their overall health but also increase the speed of growth and the size of the plant (Begich and Begich Slade, 2005-2006).

Plants have been shown to significantly increase their rate of growth when stimulated by specific sound frequencies. In the 1950's, Indian botanist T.C. Singh observed under a microscope the protoplasm streaming in an Asian aquatic plant, which normally increases at sunrise and discovered that such streaming could be induced at other times of the day by activating an electrically driven tuning fork. He then experimented with

recorded South Indian violin music played to a wide variety of plants, with frequencies of the fundamental tones in the 100 to 600 Hz range; significantly increased growth rates resulted (Tompkins and Bird, 1989). About the same time, a Canadian named Eugene Canby began subjecting test plots of wheat to recordings of violin sonatas by J.S. Bach and found that yields increased by 66%. Other tests in Russia, the U.S. and Canada with ultrasonic frequencies yielded similar increases in the growth rates of other plant species (Wicke, 2002). Scientists may find different results with different plants. Testing different species of plants and testing different types of music brings endless experiments.

Various researchers then determined that the range of frequencies around 5000 Hz were especially potent in stimulating plant growth. A Minnesota plant breeder named Dan Carlson collaborated with a music teacher named Michael Holtz to create an audio tape with a combination of frequencies centered about the 5000 Hz range, which Holtz immediately recognized as being very similar to the sound of a bird chorus at dawn. Carlson then used this music to induce record-breaking growth rates in Purple Passion vine plants (Tompkins and Bird, 1989).

Talos collected some references about sound and plants in his article about corn (Talos, 2001). The effect of music on the growth and yield of paddy has been studied by Subramanian *et al.* (1969). Paddy is indifferent to daily 30 min exposures to recorded South Indian oboe music (Subramanian *et al.*, 1969).

In 1973, the book *The Sound of Music and Plants* was written by Dorothy Retallack on scientific experiments involving plants and music. In her experiments she played sounds and particular styles of music for plants. She gained best results from classical music (compositions of J.S. Bach, Haydn, Beethoven, Brahms, Schubert and other European 18th and 19th century composers) and traditional North Indian music performed on sitar and tabla (Robertson, 1998).

Retallack also found that the discordant music of 20th century composers Arnold Schonberg and Anton von

Webern also caused plants to atrophy, but not to the degree of the rock music. Schonberg is considered to be the father of 12 tone music which is called negative music. The 12 tone style is what gives music for horror and suspense films its particular capacity to shock and terrorize (Wicke, 2002).

Effects of the intensity of audible sound on the growth and development of Rideau winter wheat was investigated by Weinberger and Measures (1979). They reported that a variety of sounds at 90 db had little effect, but plants subjected to 105-120 db showed reduced growth. In the study with *Arabidopsis*, it was found out that Talking Heads music at 60 db for 1 min did not induce expression of touch-sensitive genes (Braam and Davis, 1990). In this study we played classical music between--74.6 db to *Allium cepa* and they showed better growth than control. Jones (1991) reported how music might be used as an herbicide, claimed that Charles Darwin played the bassoon for *Mimosa pudica*. Davis and Scott (2000) studied the influence of music on germinating seedlings and seedling growth. Their researches showed that music makes seedlings grow faster, but the response is quite species-specific.

French physicist and musician, Joel Sternheimer, discovered the mechanism for how plants respond to the stimulation of sound waves. Sternheimer composes musical note sequences which help plants grow and has applied for an international patent covering the concept. The patent includes melodies for cytochrome oxidase and cytochrome C which are two proteins involved in respiration. It also includes sound sequences for troponin C which regulates calcium uptake in muscles. Further, a tune was developed for inhibiting chalcone synthase which is an enzyme involved in making plant pigments. Each plant type has a different sequence of notes to stimulate its growth. Playing the right tune stimulates the formation of a plant's protein (Begich and Begich Slade, 2005-2006).

The root elongation is also relative to cell metabolism (Seregin and Ivanov, 2001). There was positive change in the length of the adventive roots as we compared them with the control. But onions those exposed to frequently reprinted and opus with rhythmic dynamically changing lyrics which contain more extensive kvinta septa oktava intervals were shown better growth and also had higher mitotic index value. pH is one of the important factors for water cultures. Optimum pH values are among 6-8. For this reason we used water which has optimum pH to neglect the effects of pH to plants.

In conclusion, plants grow faster in exposure to positive music. The knowledge can be applied in

agriculture to increase the yield. This idea may help to solve problem of starvation and world hunger in the future.

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