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THE INFLUENCE OF MUSIC ON SEED GERMINATION OF *BETA VULGARIS* L.VAR. *CICLA* L.

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Abstract

In horticulture, recent technological advances has inevitably led to studies and research conducted on plants interactions with the environment, and further to the development of new theories and assumptions regarding the plants ‚senses'. A large part of the experiments conducted worldwide represents those that aim to understand the effects of music on plant growth, in various stages of development.
In this context, the present paper aims to describe the influence of different types of music on the germination of Beta vulgaris L.var.*cicla* L. *seeds. The seeds were divided into three groups (five seeds in each group), one subject to the experimentation and two control groups. Two control groups were chosen in order to establish if any differences could be noticed according to their proximity to the music source. The observations were taken twice a day, for 28 days, the total period of the experiment. Notes, photos, measurements for a better and fair description of the experiment have been taken. The results where rather unpredictable, proving the effect of music on plants in an unexpected way.*

Key words*: Beta vulgaris, music, stress, germination, growth.*

INTRODUCTION

In the vast domain of horticulture, technological development and the ease of global information exchange have contributed to a shift and development in man's idea of 'plant organism'.
It was discovered that plants can 'hear', 'see', 'move', facts considered quite surprising and often enough at the fringe of scientific acceptance. However, because of these abilities, plants started to be seen as complex beings, capable to feel, interact with one another and their environment.
Many experiments studied the connection between sounds and the development of plants. Jagadis Chandra Bose, indian physicist, biologist and botanist, dedicated his life to the study and research of plants' responses to environment stimuli.
Among others, he reached the conclusion that plants react to the attitude of those with whom they interact. It was also proven that plants are sensitive to external factors such as light, cold, movement, noise. J. C. Bose documents his research in books like *Response* in *the living and non-living (*Bose, 1902) published in 1902 and *The nervous mechanism of plants (*Bose, 1926), published in 1926.
In the same frame of mind, american botanist and horticulturist Luther Burbank studied the way in which plants react when thy are taken out of their natural habitat. He used to speak to his plants. Based on his experiments, he assigned approximately 20 sensory perceptions to plants (Burbank, 1939).
So, if plants are capable to respond to different stimuli, are capable to have sensory perceptions and interaction, how do they respond to sound waves and the vibrations created by music?
Various studies have tried to answer this question, focusing especially on music's influence on the growth of plants.
In 1962, dr. T. C. Singh, chief of the Botany Department of the Annamalai University in India, experimented with the effect of sounds on plant growth. He discovered on balsa plants, that the rhythm of growth accelerated with 20% for height and 72% for biomass, when exposed to music. Initially, he experimented with classical music. Later, he tried ragga, flute, violin, harmonica and reena, an indian

instrument. He discovered similar effects. Singh repeated the experiment on cereal crops, finding the crop to grow by 25-60% above the regional average.
As a result of many experiments, Singh concluded that the violin has the biggest impact on plant growth. He discovered that 'feeding' the seeds with music before and during germination, will result in bigger plants with more leaves.
Experimenting in the same time period as Singh, the canadian engineer Eugen Canby exposed wheat to J. S. Bach's violin sonata and observed a 66% growth in the rhythm of the plants' development (Robertson, 1998).
In 1973, Dorothy Rettalack developed an experiment within the Women's College in Denver, using three biotronic control rooms. She exposed three groups of plants to different types of music sounds. The first group had the musical note E played for 8 hours a day. The second group had the same note broadcast, but for a period of 3 hours a day, while the third group was left in silence.
The findings showed the first group to die within 2 weeks from the start of the experience and the second group of plants to be healthier than the control one.
Plants exposed to Hayden, Beethoven, Brahms and Schubert, grew towards and around the speakers. Those exposed to country music showed no reaction. Jazz seemed to have a beneficial effect, stimulating growth. A different group of plants grew away from the speakers which played rock music. The plants seemed to try and climb the glass walls, in an attempt to escape the noise.
Dorothy Retallack repeated the experiment with rock music on various species. She observed an abnormal vertical growth, smaller leaves ad lessions associated with excessive water absorption. No matter which direction they were turned to, the plants would grow away from the rock music.
These discoveries were documented in Dorothy Retallack's book ' The sound of music and plants' (1973), (Retallack, D.L., 1973).
In the well known TV-show 'Myth Busters' a similar experiment was developed which concluded that plants react positively on any type of music.
The famous book 'The secret life of plants' (1973) written by Peter Tompkins, Cristopher Bird, describes among others the sense of 'hearing' in plants. How do plants hear? The sound is transmitted as waves that move through a medium (the cytoplasm) and determine the movement of the particles found in this medium. When humans hear, sound waves create vibrations in the air making the eardrums vibrate. This pressure energy is transformed in electrical impulses translated by the brain.
In a similar way, the pressure in soundwaves creates vibrations picked up by plants. Plants do not hear music. They feel the vibrations of the sound wave. These, in turn, modify the protoplasm's movement inside the cell, modifying the sysnthesis of nutritious substances and therefore the development of the plant.(Tompkins and Bird, 1989)
Different sounds have different frequencies and different pressure degrees, so many ways in which they can influence the growth of plants.
DeMorgenzon wine estate, in Stellenbosch, South Africa, uses baroque music since 2008 to enhance the grape's maturation process. Not only for the plants but also for the soil. The vibrations help with the production of useful bacteria and fungi in the soil, fact that encourages a strong root formation and as a result a healthy growth of the plants (DeMorgenzon Wine Estate, 2017).
Paradiso di Frassina in Toscana, Italy, also uses classical music in order to obtain a better production. They observed that plants mature faster when exposed to Mozart, Vivaldi, Hayden, Mahler. They broadcast music 24 hours each day, without negative effects (Al Paradiso di Frassina, 2017).
Starting from these premises, the present study represents a first experiment which is looking to investigate the influence of music on the germination of Beta vulgaris L. var. cicla L. seeds, in order to verify the theories proposed by all these researches throughout the years. The purpose is to accumulate more data and use the information gathered in the future planning of different plant crops.

MATERIALS AND METHOD

Because the experiment took place in December, a cold month with short days, Beta vulgaris L. var. cicla L. seeds were chosen, commonly known as 'chard'.

Part of the Chenopodiaceae family, this plant is closely related to spinach, known for its ability to germinate and start its vegetation cycle at relatively low temperatures (around 10ºC).

The following materials were used:

- 3 glass aquariums (A1, A2, A3) with the following dimensions: 30x10x25.5 cm(A2) and 33x12x26.5 cm (A1 and A3);
- egg cartons for soundproofing the aquariums;
- duct tape and thread;
- iPod and headphones to play music in one of the aquariums;
- camera and tripod;
- organic, pre-fertilized soil, with pH=6.6;
- distilled water for watering the plants and keeping the soil's pH constant;
- 3 thermometers for each aquarim;
- measuring jar for water;
- plotting paper;

The experiment too place in a west-oriented room, which allowed the plants to receive direct sunlight few hours in the afternoon.

It was decided that there will be 5 chard seeds in each of the three containers.

Aquariums were chosen, so that each growing medium could be somewhat isolated from the rest. The first aquarium (A1), designated the experiment group held the seeds that were going to germinate in the presence of music. A2 and A3 were set as control groups. Two were chosen because whenever the room was being set up, there were three empty aquariums available, and it was envisaged that differences between the two could be observed, depending on their proximity to the music source.

The three containers were placed on a table, facing the window, one next to the other, in the following order: A1, A2, A3. They were set up on egg cartons, useful to absorb the sound vibrations. Also, they were separated and covered with the same materials, to maintain a phonic medium specific to each aquarium: A1 with music, A2 and A3 without. In the first aquarium the headphones connected to the iPod, were attached to the cardboard ceiling, the music being broadcast from above the plants.

Plotting paper was stuck on the eastern (back) side of the aquariums, in order to measure the height of the plants emerging.

All 3 aquariums were treated identically. They had the same type of soil, they were watered constantly with the same amount of water, they were provided with the same quantity of heat and light, being set at equal distance from the heater and window.

Distilled water was chosen so that the soil's pH will be kept constant, considering that the soil was fertilized in advance. The seeds and young plants were watered according to their need, temperature, humidity inside the aquariums. They were watered in the morning, but not at equal intervals, considering that some days were warmer or colder, the water evaporated quicker or slower. Because the containers lacked a drainage system, it was taken care so that water doesn't accumulate in excess, so that the soil becomes soggy. With the graded jar the same amount of water was distributed to all three containers. During the experiment no fertilizers were used.

The temperature inside the aquariums was measured with a thermometer placed inside each of them, and it fluctuated between 15-20ºC at night and 16-24ºC during the day. In the first 8 nights the heater was turned to ensure the cold will not interfere with the germination. The temperature reached 20ºC.

The experimental variable – the music – was broadcast in A1 through a pair of headphones connected to an iPod.

Bach was chosen, due to previous experiments (see introduction) which confirmed the composer's beneficial effect on plants. The pieces of music were the same, repeating each day: Johann Sebastian Bach, Goldberg Variations; Brandenburg Concertos no. 1-6; Mass in B minor; Minuet and badinerie; Prelude in C; Toccata in D. In order to test the effect music has on the germination of chard seeds it was decided to keep the music on for a duration of approximately 10 hours each day. The iPod was turned on every morning around 7-7.30 and turned off in the evening around 17-18.00, for a total of 28 days.

All the aquariums were photographed on a regular basis, to observe the rate of germination and growth of the seedlings, at the same time constituting proofs for the evolution of the experiment.
The containers were set up and the music turned on for the first time on the 15th of November 2016. the experiment ended on te 13th of December 2016.

RESULTS AND DISCUSSIONS

During the fifth day, three emerging plants were observed in A1. They were grouped together, right under the headphones. At first sight it seemed quite strange because there were 5 seeds placed in each aquarium, with approximately 5 centimeters in between. So, the first seeds to germinate were the ones in the experimental aquarium.
The following day, in A1 another plant appeared and in A2 two solitary plants and a group of 4 plants. In A3 a group of three seedlings and a solitary one emerged. The days in which new plants were noticed to have emerged are organized in Table 1.1. After the 13th day the seeds stopped germinating and no other plants appeared.
At the beginning, the first five days from germination, all plants had the same development rate and the same vitality. In spite of this, during the 17th day (2.12.2016) a loss of vitality was observed for the six seedlings in A1. No signs of abnormalities were found inside the aquarium like yellow leaves, mold, parasites, neither were there any substances used, aside distilled water.
The condition worsened during the following days and only for these plants.
These looked like they couldn't sustain their own weight, they grew in height but couldn't stand straight, their stems looked somewhat wavy, while the plants in A2 and A3 had straight stems. Figure 1, figure 2 and figure 3 will show the state of the plants in all three aquariums in the 17th day.
During the following days the chard seedlings slowly lost their mechanical capacity to sustaintheir own weight and fell to the ground. Once more, this condition was only present in A1.

Table 1.1 The emergence of new plants in each aquarium. With 'g' were noted those plants which germinated in groups from the same compound seed. 'P' are those plants which germinated alone from one seed. 'Pl' are the plants in one group. As an example: on 20.12.2016 in A1 there were 3 plants germinating from the same compound seed forming 1 group.

Date		A1	A2	A3
20.11.16 (Day 5)	g	1x3pl		
	p			
21.11.2016 (Day 6)	g	1x3pl	2x4pl	1x3pl
	p	1	2	1
22.11.2016 (Day 7)	g	2x3pl	1x3pl, 1x4pl, 1x2pl	1x3pl
	p			1
24.11.2016 (Day 9)	g	2x3pl	2x3pl, 1x4pl, 1x2pl	1x3pl, 1x2pl
	p			1
27.11.16 (Day 12)	g	2x3pl	1x3pl, 2x4pl, 1x2pl	1x3pl, 1x2pl
	p		1	1
28.11.2016 (Day 13)	g	2x3pl	1x3pl, 2x4pl, 1x2pl	1x3pl, 1x2pl
	p		1	2

To observe the plants' evolution in time, a comparison between figure 1, figure 2 and figure 3 (day 17) and figure 4, figure 5 and figure 6 (day 25) should be made. The difference between the plants in A1 and those in A2 and A3 can be clearly seen.
Considering the height of the plants and analyzing the photographs and data, at a first glance it may appear that the plants in A2 grew fastest, comparing them with the seedlings in A1 and A3. But this impression is insubstantial because in the second aquarium there simply are more plants.
As an example, during the 17th day the seedlings in A2 presented heights between 5 and 7 cm. A1 and A3 had five plants each, with heights between 4 and 7 cm, therefore the same length. Because of this, the height of the plants cannot be considered as a cause for the weakening of the plants' tissue.
Moreover, it is difficult to verify whether this variable was affected by the exposure to music.

As a result of germinating first, the plants in A1 were supposed to grow taller, but the collected data found this to be untrue.
During the 22 days of growth, the plants' development didn't pass the cotyledon stage. This fact can be attributed to the season in which the experiment took place, the natural light in this period not being sufficient for a heathy and normal growth cycle.
No artificial lighting sources were added due to a lack of funds.

CONCLUSIONS

The objective of the experiment was to follow the effect music has on plants, for possible future applications.
During the 28 days, the music's influence on the chard seedlings was clearly observed, an influence that could only be explained by the presence of music.
Firstly, it is important to note the fact that the seeds in the experimental aquarium were the first ones to germinate. It is true that the difference between A1 and the control groups was of only 1 day, but this fact cannot be seen as a coincidence.
The enviromental conditions were the same in all 3 growing mediums.
It is possible that the music stimulated in some way the plants' embryos, motivating them to germinate. Secondly, the unexpected turn things took in A1 after 7-8 days of growth, signals a negative influence of the sound waves over the seedlings.
One hypothesis is that the music source was too close to the plants, causing them some kind of phonic stress.
It is also possible that the number of hours the music was played for daily, to have interfered with the plant's normal life cycle. However, it is certain that the plants state was not normal, indicating a real problem inside the aquarium.

Figure 1. Plants in A1 in the 17th day

Figure 2. Plants in A2 in the 17th day

Figure 3. Plants in A3 in the 17th day

Figure 4. Plants in A1 in the 25th day

Figure 5. Plants in A2 in the 25th day

Figure 6. Plants in A3 in the 25th day

This problem existed only in A1, fact prooven by the photographs taken during the experiment. Interestingly enough, the studied bibliography did not indicate any negative effects in relation to the number of hours of music exposure, nor did they mention any increases in sensitivity of the young plants to music.

On the contrary, the literature states the pozitive effect Bach's music has on the development of the plants.

As mentioned in Results and discussions, until the collection of new data, the hypothesis remains that the Beta vulgaris L. var. cicla L. seedlings lost their mechanical capacity to sustain their own weight due to the phonic stress they were exposed to. In order to establish whether the duration of the 'music hours' was the culprit, the experiment should be repeated by testing the length of music exposure on different groups of plants.

In conclusion, this experiment confirmed once more music's influence on plant development . It was observed how these organisms modify their life cycle as a response to external sound stimuli.

Even if the results are slightly surprising and different from those of previous researches, our team considers that studies on this domain are as diverse as plant species and music genres.

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