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Original Paper

A Project for Life Sciences Students and Physics Students Involving a Cell Phone

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Abstract

An increasing number of life science students are taking physics courses in college as more physics-based medical technologies are being implemented in hospitals and clinics. Most of these students are unable to appreciate the connection between physics and their fields when taking a typical physics course. One of the best ways to bridge physics with another area of study is to involve students in a small but exciting research project such as relating the physics of microwaves to biological organisms. A cell phone was used to study the effect of its emitted microwaves on the growth of tomato plants after exposing the seeds to the signal during germination.

Keywords

Interdisciplinary Education, Introductory College lab project, Undergraduate research

1. Introduction

It is important that we emphasize the application of physics to biology and health when teaching introductory physics courses to life-science students. One of the most interesting applications is the effect of electromagnetic waves, such as microwaves, on humans. Almost all students have cell phones and they get anxious when they realize that these phones emit microwaves. In this study, a biology student and his physics professor conducted this research to understand the effect of cell phone signal on tomato plants. Plants and humans are both biological organisms and one may use plants to have some indication on what may affect humans.

The exposure to microwaves at the frequency of cell phones have increased from natural levels by a factor of about 10^{18} due to man-made cell phones and other wireless devices (Bandara, 2018; Philips, 2012; Raines et al., 1981). Microwaves are non-ionizing waves that cause thermal heating in

microwave ovens which operate at a frequency of about 2.54 GHz. Cell phones however operate at frequencies of about 1 GHz and with much less power than microwave ovens—they do not cause heating effects giving the impression that they are not harmful. However, some studies have proven that cell phone signals can have an impact even with the absence of a thermal effect. Viokow et al. (2011) for example, showed that exposure to a 50-minute cell phone placed on the ear of a person increased brain glucose metabolism in the region closest to the antenna, though the clinical significance of this finding is not known. Many other studies suggest that cell phone signals are harmful to animals (Aldad, 2012; Esmekaya, 2011; Mith-Roe, 2017; Ruediger et al., 2009) while other studies did not show any effect on animals or humans (Hirose et al., 2008). Though plants are biological organisms, few studies have been conducted on them. These studies resulted in various conclusions in regards to the effect of cell phone signal on germination, plant growth, etc. (Jonas, 1952; Haggerty, 2010; Vian et al., 2006). All these studies used microwave transmitters, but we used a cell phone instead to mimic real life situations.

2. Experimental Conditions

We chose to study Washington Cherry tomato plants because they are responsive in a relatively short period. All seedlings and growing plants in this experiment were grown in a BioChamber GC-16 growth chamber that allowed us to set temperature, humidity, CO_2 levels and lighting. Nutrient, light and temperature factors remained the same for all experiments. The growth chamber was set to a temperature of 24 ℃, CO_2 of 350 ppm, and humidity of 50%. A Motorola cell phone that has an exposed antenna was used with AT&T service at an operating frequency of 890 MHz. The reason we used a phone that has an exposed antenna so that the student can place the antenna near the plants instead of guessing where the antenna is if we use a modern phone.

3. Procedure and Results

A filter paper was placed in an empty 10 cm - diameter petri dish and then dampened with ionized water. Twenty-five seeds were placed in a grid approximately 1 cm apart and then the dish was tightly wrapped with parafilm. We exposed these seeds to the cell phone signal during germination and labeled them “Germination Exposed—Batch #1”. The same was repeated for another 25 seeds in a separate dish labeled “Control—Batch #1” which would not be exposed to cell phone signal.

The cell phone was placed such that its antenna was directly over the 25 seeds of the “Germination Exposed” petri dish as shown in Figure 1. A computer was arranged to make about 315 min. of phone calls during the 72 hours of the germination period. We selected at random ten of these 25 germinated seeds and buried each seed in a cell of soil placed in a Perma-Nest tray. The 25 “Control” seeds were germinated for 72 hours without exposure to the cell phone signal, then 10 seeds were selected at random and likewise buried in separate cells of a Perma-Nest tray parallel to the “Exposed” seeds as shown in Figure 2. The above experiment was repeated two more times; we will refer to them as Batch

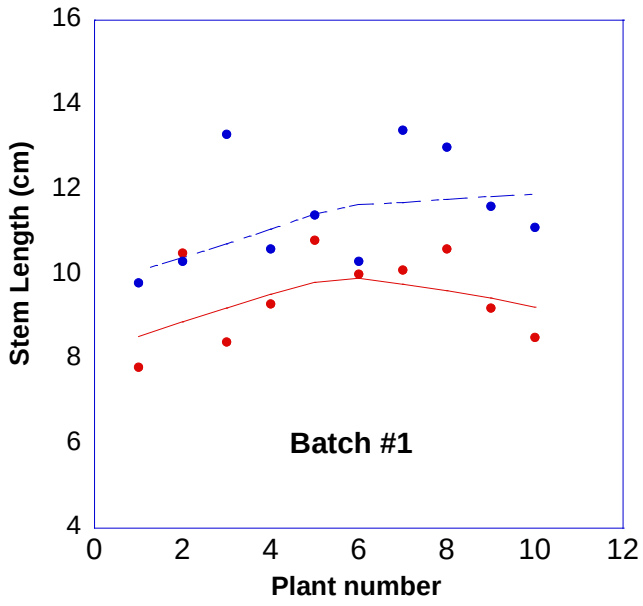
#2 and Batch #3. The three trays for Batch #1, #2 and #3 were placed into the growth chamber, with conditions described above, and were allowed to grow into plants for 35 day without exposure to the phone signal during growth.

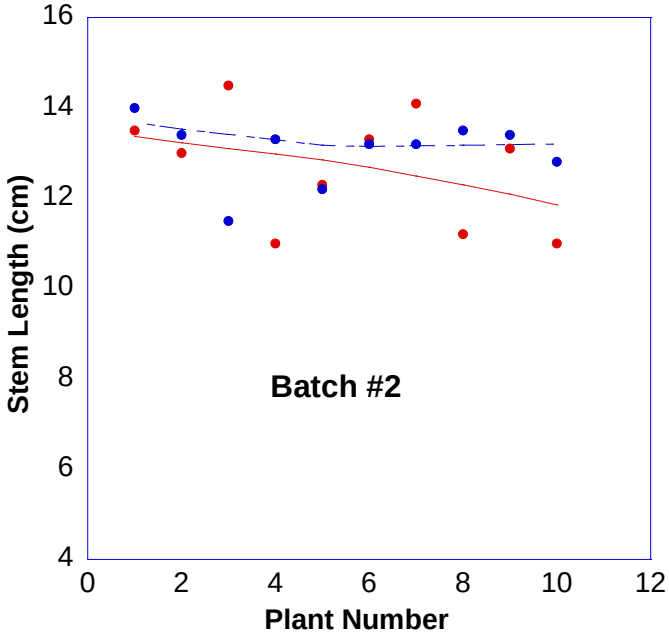
Figure 1. Tomato Seeds Germinating in a Dish While Exposed to the Signal from the Antenna of a Cell Phone

Figure 2. The Figure Shows Two of the Three Batches. The "Germination Exposed" and the "Control" Plants Are Facing Each Other in Each Tray

After 35 days of growth above ground, the stem lengths of each plant of the "Germination Exposed" plants and of the associated "Control" plants were measured. The Stem length of Batch #1, #2 and #3 are plotted in Figure 3 versus plant number (the Germination Exposed plant is given the same plant number as the Control Plant that is facing it in the tray).

We can see from Figure 3 that for each of the three batches, the stem lengths (red dots) of "Germination Exposed" plants were in general less than those (blue dots) of the Control plants. We used the function "Weight" in the KaleidaGraph software to draw the red and the blue lines to guide the eye for the trends of the data.





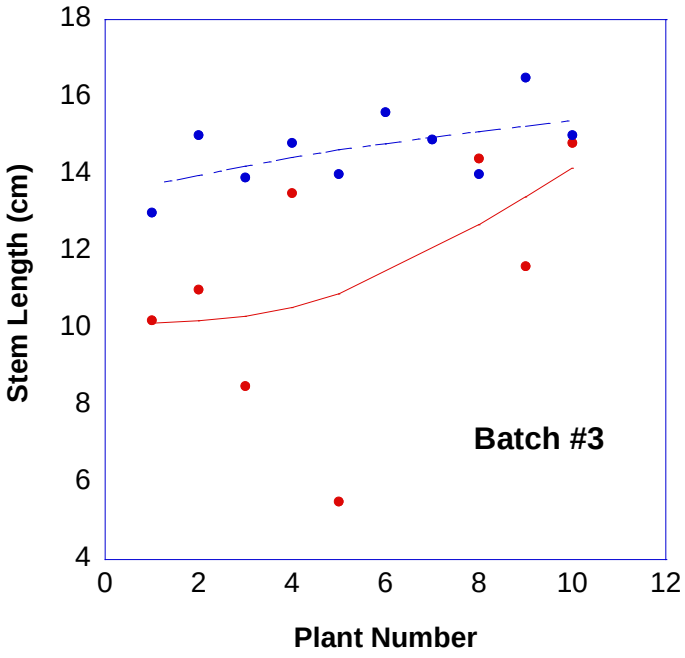


Figure 3. The Steam Length for the Three Batches. The Red Represents the Germination Exposed Plants and the Blue Represents Their Associated Control Plants. We Have Two Missing Red Points from Batch #3 Because Two Plants Did not Grow above Ground

For a rough analysis, we took the average of the actual values of the red dots and the average of the actual values of the blue dots of all three batches and found that the average stem length of the "Germination Exposed" plants (red dots) is shorter than that of the Control (blue dots) by about 20%. Interestingly, there are studies that showed the effect of microwaves radiations on the growth of plants such as a study that exposed Oil Bearing seeds to RF radiation and found increased rates of germination (Jonas, 1952). Another study (Haggerty, 2010) on the effects of RF radiation on Aspen plants found that exposed plants displayed a reduction in shoot length and leaf area.

4. Discussion

From physics point of view, the microwaves emitted by a cell phone should have some effect on plants. That is because the magnetic field of microwaves oscillates and according to Faraday's law of induction, an oscillating magnetic field induces electric current—this induced current in the seeds during germination perhaps was the cause for shorting our plants. Since the human body is a living organism like plants, students should be encouraged to think that the induced current induced by the cell phone may have some effects in our bodies when we use such a phone. This effect however might be very small and unnoticeable—as mentioned in the introduction, scientists so far do not agree about the consequence of the effect of cell phones on humans.

We recommend that this interdisciplinary project be conducted as part of introductory biology labs or introductory physics labs in collage to show the applications of physics on living organisms. Only a non-expensive cell phone and a controlled space to grow the plants are needed to do this kind of work.

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