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Article

Electromagnetic Radiation From Electronics Does Affect Plant Growth

Akshya Mahadevan[1] & Mr. Gregory Young[1]
[1] Roberto Clemente Middle School, Germantown, Maryland

SUMMARY
Global warming is becoming an increasingly prominent issue. It is commonly disputed whether electronics and the radiation they emit are harmful towards the growth of organisms. As this cannot be tested on a human, we chose plants which are a key element of Earth. To be specific, this research was conducted on basil plants. The purpose of this experiment is to find out if electromagnetic (EM) radiation from electronics affects plant growth. After experimentation, it can be concluded that EM radiation did affect basil plant growth. The plants exposed to EM radiation were taller, thinner, and a much lighter shade of green compared to the unexposed plants. With the help of this experiment, the effects of EM radiation on the growth of organisms can be seen and studied. Further study is necessary to determine if the EM radiation affected the plants on a molecular level, as well as understand how they adapt or if they die. This research can be used to determine the potential detrimental effects that electronics can have on living organisms and the environment to eventually help create a solution to reduce or eliminate this harm.

INTRODUCTION

Much of the ecosystem relies on plant growth. Plants are the main producers of oxygen and organic compounds. Ensuring the health of these organisms is vital. Recent technologies could be damaging them, which is what this research intends to find out. Cell phones emit microwave (type of light) radiation. Cell phones transmit about one to two watts of power in the range of 824 - 1780 MHz. Computers emit infrared radiation in the range of 410.0048 - 900.0074 THz due to processes such as the device becoming heated, the Bluetooth antenna, and the display (1). Multiple experiments have been conducted, using lentils to soy beans to chili plants, to be able conclude EM radiation does affect plant growth with varying results, mostly negative. Due to mixed results from previous studies, scientists still debate much on whether EM radiation affects plant growth or not.

An experiment conducted with fenugreek seed and pea plants to see which one grew faster and healthier consisted of exposing multiple plants of one species to different amounts of EM radiation. This study concluded that mobile phone radiation does cause changes in the morphology and biochemistry of the plants since the plant height, germination, seedling vigor, root length, and biomass % decreased (2). Scientists conducted a similar experiment with lentils. There were several discrepancies in the EM radiation-exposed plants in comparison to the unexposed plants. For example, only 10.35% of the seeds germinated, while the control group had a germination rate of 22.85%. They also observed many mitotic abnormalities in the plants exposed to EM radiation (3). In another study, researchers analyzed plants near the remains of a nuclear reactor and found that the soybeans had adapted to the new conditions. To retest this, they planted soybeans at the 5 km point and the 100 km point from the remains of the reactor. There was 163 times less cesium-137 in that area. The results of this experiment deduced the soybeans next to the nuclear site had adapted to their environment. The soybeans weighed half as much and took up water much slower compared to the soybeans exposed to little to no radiation. On the molecular level, they were even stranger. The soybeans exposed to high levels of radiation had three times more cysteine synthase, which protects the plant by binding heavy metals. They also had 32% more betaine aldehyde dehydrogenase, a compound found in human blood when exposed to radiation that reduces chromosomal abnormalities. They also had fluctuating amounts of seed storage proteins, a source of nitrogen for germinating seeds, compared to a regular soy plant (4). An experiment in Kolkata, India, tested 50 chili plants with exposure to EM radiation from the seed stage to fully grown. They exposed the plants to over 71,954 minutes of radiation over the course of 50 days. This experiment had highly mixed results as the plants and leaves grew taller and longer, but were duller in color and wrinkly (5). All the results corroborated that EM radiation negatively affects plant growth. Blocking EM radiation exposure to the best extent possible is necessary for maintaining normal plant growth, as these studies have demonstrated diverse effects that negatively impact the plant life cycle.

A few plants can absorb EM waves such as the cactus, betel leaf, spider plant, sansevieria, and the stone lotus flower. NASA has proved that the cactus can absorb radioactive waves with extensive research. Betel leaf extract has proven to protect DNA from radiation by preventing radiation-induced DNA strand breaks in a concentration-dependent matter (6). The spider plant, also known as Chlorophytum comosum, can absorb a large number of air pollutants including formic acid and aldehyde. This same concept of absorption also applies to EM radiation (7). Sansevieria can harmlessly absorb 100 different types of poison and is an anti-pollutant (6). It is an antidote to certain forms of radiation. Lastly, the stone lotus flower, though small, can absorb radiation effectively (7).

This project aims to determine whether nearby sources of EM radiation affects household plants. We can also use this research to identify if the devices used by agricultural workers, assuming those devices put out EM radiation, affect crop yields, which could potentially waste money, time, and resources. Based on previous findings already mentioned, I hypothesize that if a plant is exposed to the EM radiation of many electronics, the plant will have smaller leaves, slower growth and have a weaker structure because the EM radiation will cause the plant to adapt or die. The results of the experiment supported the hypothesis. The EM-exposed plants were visibly weaker. They had thinner stems and smaller leaves. Not only that, but they were also a much lighter shade of green, though they did grow taller at a much quicker rate.

RESULTS

This study examined the effects of EM radiation on plant growth by placing a cup near electronics and a cup away from all electronics. Two identical cups were set up in each area and plant growth was measured daily for a period of 42 days. This experiment was conducted as a triplicate. The physical characteristics observed in the EM plants were weak stems, brittle leaves, and an extremely light shade of green. Plant height was significantly higher but was maintained for a longer period in the control plants compared to the EM plants for all studies (Fig. 1, Fig. 2). More germination occurred in the EM plants compared to the control plants for all studies (Fig. 3).

There was an increase in height in all of the EM plants compared to the control plants. However, as time went by, the EM plants died while the control plant heights started wilting but later started becoming taller again. Control Plant 3 never grew; none of its eight seeds germinated. Due to the death of plants earlier in the study, the data is skewed, since about 66% of the plants did not live long. Overall, the data suggests that EM radiation affects plant growth factors such as height and length of life of the plant (Fig. 2). The EM plants were taller, germinated first, and grew faster than the control plants, but did not live long. On the other hand, the control plants germinated later, grew slower, and lived much longer. The EM plants have an average maximum height of 0.958 inches while the control plants have an average maximum height of 0.6875 inches. The control plants were approximately 0.2705 cm taller than EM plants overall and taller by 0.1149 inches on a daily average. The results of the one-way ANOVAs conducted for each EM and control set shows that there is a significant statistical difference (EM 1 and control 1 : f-ratio = 6.28096, EM 2 and control 2 : f-ratio = 25.7887, EM 3 and control 3 : f-ratio = 8.89215). All of the results proved to have a p-value less than 0.05, which proved there to be a significant difference. A statistical difference can also be proven as all of the f-ratio is greater than one, proving there is more variance between groups rather than within.

EM radiation also affected plant germination since all of the EM plants had more sprouts overall, though they died much faster (Fig. 3). The average of the maximum number of sprouts for the EM cups was 6.3, while the average of maximum sprouts for the control cups was 4. Though this

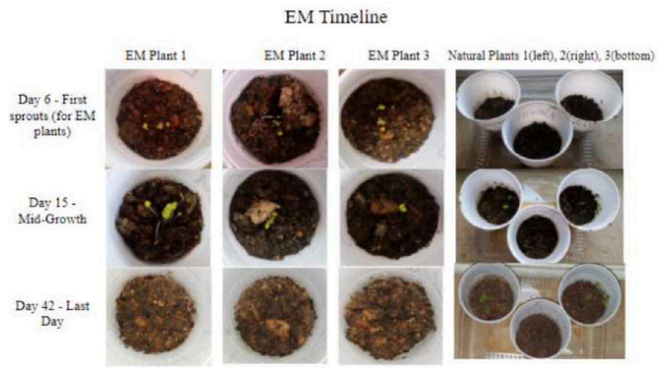

Figure 1: Timeline of EM plants and control plants. Images of EM and control plants are shown for Day 6, 15, and 42. The EM plants sprouted before control plants, the first ones appearing on Day 6. Moderate growth is visible in both groups on Day 15. On Day 42, the last day of the study, all of the EM plants had died, but control plants 1 and 2 appeared healthy. Control plant 3 never sprouted.

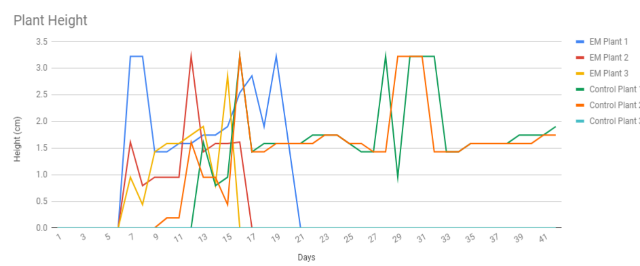

Figure 2: Timeline of EM plants and control plants. Images of EM and control plants are shown for Day 6, 15, and 42. The EM plants sprouted before control plants, the first ones appearing on Day 6. Moderate growth is visible in both groups on Day 15. On Day 42, the last day of the study, all of the EM plants had died, but control plants 1 and 2 appeared healthy. Control plant 3 never sprouted.

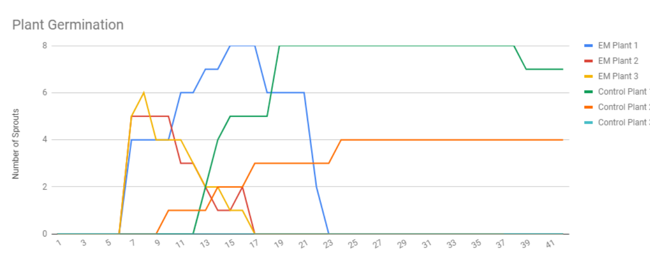

Figure 3: The line graph represents the number of sprouts and germination in the cup every day for 42 days. All trials were carried out indoors in the designated EM exposed and natural, unexposed area. Each cup can grow up to 8 sprouts. Control plant 1 and EM plant 1 were observed to hit 8 sprouts, though Control maintained it much longer.

data provides evidence against the hypothesis, human error could have played a role in the lack of germination in control plant 3. Even with the small sample size, there are significant statistical differences observed between the three sets (EM 1 and control 1 : f-ratio = 16.54675, EM 2 and control 2 : f-ratio = 25.65636, EM 3 and control 3 : f-ratio = 9.64706). All of the results also proved to have a p-value less than 0.05 and a f-ratio greater than one, which proves there to be a significant statistical difference.

DISCUSSION

EM radiation affects plants in many different ways, both positive and negative. The germination levels increased by 57.5%, though human error could have played a role since none of the control plant 3 seeds sprouted. The height of the plants also differs greatly between the groups. This shows that EM radiation tends to make plants grow a lot faster, though they died much quicker. The results both contradict and agree with previous experiments. The basil grew slightly taller when exposed to EM radiation, similar to the experiment conducted in Kolkata. However, the plants also died much quicker, supporting the other experiments. This could have been due to the fact that basil has not been tested yet, as all of the experiments used other plant species. The physical characteristics of the EM plants could have been due to destruction or mutations of chloroplasts in the plant's leaves as chloroplasts allow for photosynthesis and the green color of plants. EM radiation could also be changing the plants' genetic makeup since the stems grew faster but were much weaker. In an experiment conducted on the effects of EM radiation on the photosynthesis of a plant, the results concluded damage in the membrane of photosynthetic cells in the leaf, the halt of the transmission process of electrons in photosynthesis, and the decrease in potential active and photochemical efficiency (8). To confirm these results, it would be necessary to repeat this experiment multiple times, as human error and a small sample size could have played a role in the outcome of this study. Examination of the plants under a microscope would also be valuable in future studies. If a change in the makeup of the cells is present, it could have negative effects on all of the organisms that consume them. As agriculture feeds future generations, we must ensure the safety of their growth and consumption. This can be done with the use of future studies to be able to take the necessary precautions. Along with this, it is important to see if these devices affect other organisms similarly, such as humans, since it could potentially impact many lives.

MATERIALS AND METHODS

This experiment was conducted indoors with the use of two different areas. The first area, identified for the EM plants, had electronics and was in front of a window for adequate sunlight. In this experiment, we used three laptops and two phones that added up to a minimum of 2878 MHz of radiation. The devices were all functional and were active to the accordance of a 9-5 workday to model real-life circumstances. A second area, identified for the control plants, was completely devoid of electronics. This area was also in front of a window to make sure the plants would have sufficient lighting. We used six plastic drinking cups to plant basil seeds within. Each cup had three small holes the size of a pencil tip at the bottom in a triangular shape to ensure proper drainage of water. Then, we filled each cup halfway with potting soil and placed eight basil seeds on top of the soil. On top of the seeds, 1/4 cup more of soil was poured. After these steps were completed, half of the cups (three cups) were placed in the first area and the other half in the second area. The plants were routinely watered ⅛ cup of water once in the morning around 8 a.m. The soil should be damp an inch down into the soil to ensure enough water for the plant. Along with this, the number of sprouts and the height of the tallest sprout was recorded into a spreadsheet and with pictures.

To analyze the results, two line graphs and two ANOVAs were made: one of each to compare seed germination and another to compare sprout heights. The graphs make it possible to observe and note down significant trends, identify outliers, and possible errors in the data. This is how we came to the conclusion that EM radiation does affect plant growth and that human errors could have played a role in the growth of control plant 3. One-way ANOVAs were conducted to ensure there was a significant difference between the EM and control plants. As this experiment was conducted in triplicates, the respective EM and control pair were cross analyzed and compared to each other (EM plant 1 and control plant 1). If the p-value was less than 0.05, the group can be marked statistically significantly different. A statistical difference can also be proven if there is more variance between groups rather than within, meaning the f-ratio must be greater than one. Else, the groups do not have a strong enough statistical difference to be considered so.

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