Do Microwaves Affect Plant Growth?

Left to right: Wheat grass seeds treated with water that was microwaved for increasing times. Day 10

By
Lalaram Guyadin

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EnvironMentors Program
Mentor: Dr. John J. Ohab
Cardozo High School

Abstract

Microwaves are important because people use them in every day life, but microwaves might also be harmful to living organisms. There are different experiments that have been done to show that this is true but the results are not the same. Therefore this project will test if microwave will or will not affect wheat grass growth. In this experiment, we microwaved water, wheat grass seeds, or soil for increasing times (control, 15s, 30s, 1min, 2min, and 4min) and measured the length of plant growth, recorded the percentage of seeds that sprouted, and recorded the day that the plant first emerged from the soil. For the water condition, the growth of the plant increased when you microwaved the water more. For the seeds and soil, the more the seeds and soil were microwaved, the growth of the plant decreased. In conclusion, these results show that microwaves can be good or bad for living things, and future studies must be done to test why microwaved water does not harm plant growth but microwaving seeds and soil did.

Introduction

Microwaves are electromagnetic waves with wave lengths ranging from 10^8-10^{11} Hz (Moeller, 1992). According to Wikipedia (2009), “the term microwave generally refers to alternating current signals with frequencies. Microwaves have three ranges ultra-high frequency, super-high frequency, and extremely –high frequency.” A microwave oven is a kitchen supply. People use microwave oven to cook or hot food. People also use microwave to dry, and cure plywood, paint, inks, and synthetic rubber, and also to reheat blood rapidly after certain types of surgery (Johnson, 1982.) Microwaves have a similar

radiation as mobile phone and people suggest it could cause cancer (Herberman, 2008). This paper will show how microwave had affect biological organism, wheat grass.

Background Research

Previous research has not been consistent. Reddy et al. (1998) investigated relationships between microwave operating conditions and resulting seed quality in terms of germination and seeding vigour. They microwaved the wheat seed for 20, 30, 40, and 50 seconds and let them grow for 7 days in glass jars. Then, the measured the plumule and the radicle length in cm. Infected seeds not treated with microwave had 100% germination. Reduced germination and increased tissue damages also were observed by others with increased treatment duration.

Skiles (2006) exposed alfalfa plants to microwave. They grow the plants indoor for 4 months at a 27 degrees Celsius before exposure to microwave. During the 7 weeks of exposure to microwave, they measured the distance nodes of the leaves. After the 7 weeks of exposure to microwave, test and control plants were harvest. The plants were dried at 80 degree Celsius for 24h and dry weight measured. They also measured soil temperature. The results were that there were no difference between the fresh and the dry weights treatment and control. There was not no difference with the soil temperature either.

Gos et al (1997) studied how microwave frequencies between 41.68 and 41.71 GHz affected the yeast Saccharomyces cerevisiae. They used a series of test chambers with a controlled exposure system and found no difference between cells exposed to microwaves and those that were not.

Magone (1996) studied duckweed grown in flasks outdoor, 2km away from a radio station transmitter. They used a frequency and intensity of the radiation which was 156-162MHz and 0.1-2.6uW/cm^2 and observed an increase in vegetative reduction rates, what they term “growth disturbance”.

Murakami et al (2001) studied Brassica campestris (known as Brassica Rapa var. silvestris in the US). They used an enclosure with the broadcast antenna supporting on a outdoor pole with a frequency of 2.45GHz with an intensity between 1.0 and 15.0mW/cm^2. They observed slight growth acceleration at the lowest intensity which they attribute to a slight increase on the soil temperature. They saw wilting of plants at the center of the enclosure, but were unable to determine if this was due to soil warming or to drought.

Urech et al (1996) studied the lichens Parmelia tiliacea and Hypogymnia physodea in field experiments of duration ranging from 1 to 3 years. They fond reduced growth rate due to thermal effects.

Picazo et al (1999) investigated the electromagnetic fields on thistles and lentils. They found that the thistles decreased in both weight and length and the stem length of lentils increased over 3 weeks.

This experiment will test how microwaves affects the growth of plants. This will be done by microwaving the water, soil, and seeds for different times and measuring the length of the plant. Also, how much seeds will grew in each container (three seeds in each container). The hypothesis is that by microwaving water, soil, and seeds, it will cause the plants not to grow.

Experimental Methods

50 grams wheatgrass seeds and a Jiffy Greenhouse 72 were purchased from The Garden District. Each Jiffy Greenhouse 72 had 72 all-natural Jiffy pots and peat pellets. Each peat pellet contains 100% biodegradable sphagnum peat moss and wood pulp. 80 3oz (88.7mL) CVS brand plastic cups, 6 BD Biosciences 5mL syringes and 1 BD Biosciences 1mL syringe were purchased from CVS/Pharmacy. The permanent markers, microwave oven, tape measure, tap water, scissors, paper towels, and Canon Digital Elph digital camera were already owned.

Methods

There were three experimental categories: microwaved water, seeds, and soil. Each category was treated with microwave radiation for 0 seconds (control), 15 seconds, 30 seconds, 1 minute, 2 minutes, and 4 minutes. Each microwave condition was repeated three times with three different cups. Each cup contained three seeds. These large experiments is really three seeperate experiments in one. In each case, the independent variable is the time that we microwave the water, seeds, and soil. The dependent variable is the growth of the plant over time, how many seeds sprouted in the container, and the first day that you can see the plant grow through the soil. These experiments were organized according to the following matrix

Figure 1. Experimental Matrix

		Water			Seeds			Soil		
Microwave time	0 seconds	A1	A2	A3	A4	A5	A6	A7	A8	A9
	15 seconds	B1	B2	B3	B4	B5	B6	B7	B8	B9
	30 seconds	C1	C2	C3	C4	C5	C6	C7	C8	C9
	1 minute	D1	D2	D3	D4	D5	D6	D7	D8	D9
	2 minute	E1	E2	E3	E4	E5	E6	E7	E8	E9
	4 minute	F1	F2	F3	F4	F5	F6	F7	F8	F9

First, we take out the materials from the plastic bag, removed the cups for their wrapper. Removed the Jiffy Greenhouse 72 from its plastic container. We originally were going to use the Jiffy Greenhouse 72 because it was small, easier to move the experiment, and it was more compact. We thought when you water each pellet individually, the water would stay in one of the wells. However, the water mixed with water meant to be for other seeds. So, we used the cups so we could water seeds for different conditions separately.

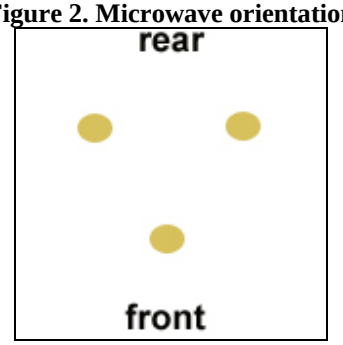
Next, we separated the cups into the water, seeds, and soil groups. Then we labeled the cups according to the numbers (0-9) and letters (A-F) on the experimental matrix in Figure 1. We did this so we did not mix up the treatments and water stayed separate for each condition. We arranged the cups into the experimental matrix in Figure 1. The reason we labeled the cups was to remember which group each seeds were in.

For the seeds category, we placed one peat pellet in each cup and we added each cup 35 mL of room temperature tap water using a 5 mL syringe. The peat pellet was so hard that we couldn't put seeds into it. We put the water into the peat pellet 5 minutes before adding seeds so it could absorb the water. Each pellet was originally surrounded by burlap. When water was added, the pellet absorbed and swelled, making the soil softer, and the burlap spread out and covered only part of the top of the soil. The burlap was cut to remove the burlap on top of the soil so the seeds could be planted.

Next, we microwaved the seeds. Each condition was microwaved separately. The three seeds were positioned in a triangle in the microwave on a paper towel so they could get the same microwave radiation (see Figure 2). The microwave was set for the corresponding time (0 sec, 15 sec, 30 sec, 1 min, 2 min, or 4 min), and the seeds were

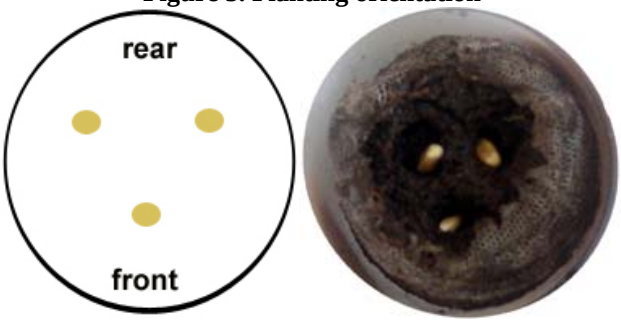
microwaved. The seeds were taken out after the time expired and allowed to cool to room temperature. When they finished cooling, they were planted in the soil. The 1mL syringe was used so the hole that the seed was in would have the same measurement each time. The tip of the syringe made the hole (Figure 3). Then we put the seeds in the holes (Figure 3) and covered it.

Figure 2. Microwave orientation



For soil category, the seeds were not microwaved. We microwaved the soil in the same orientation as the seeds were in the previous experiment and for the same times. Then we let is sit until it was at room temperature. Then, we poured water in it, let it swell, cut the burlap off with scissors, used syringe to make the holes. Then we planted the seeds and cover it with soil.

Figure 3. Planting orientation



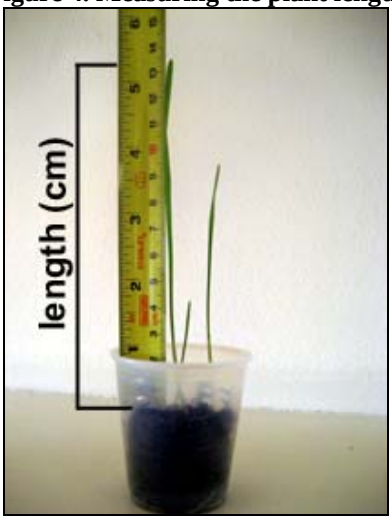
For the water, the pellets were placed in their cups. Then, we microwaved the water in the same orientation as seeds/soil for the same times. We took the water out of the microwave and allowed it to cool to room temperature. Then, we poured water in the

pellets, let it swell, cut the burlap off with scissor, used syringe to make the holes. Plant the seeds and cover it. The plants were placed in a livingroom by the window to receive sunlight every day.

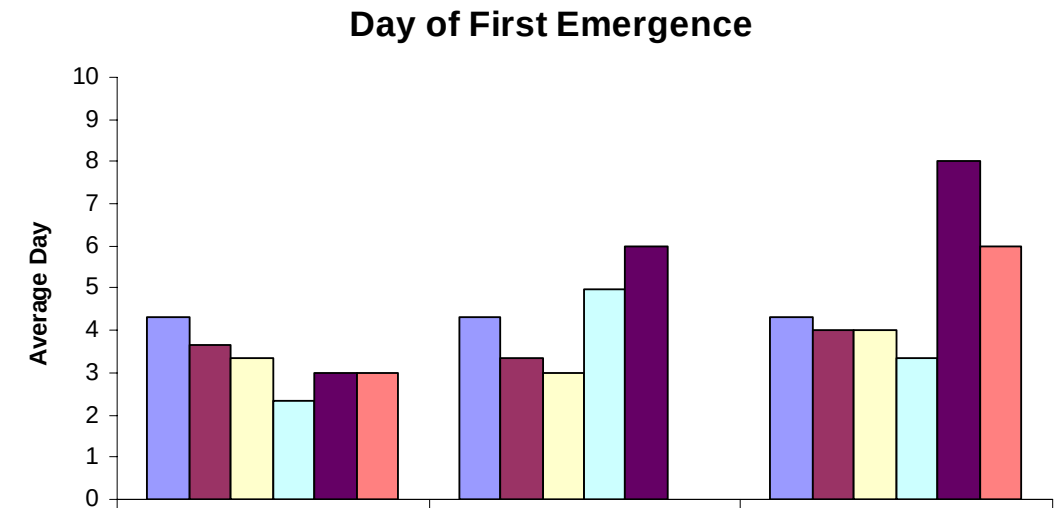
Watering: For the rest of the experiments, we watered the seed and soil conditions with tap water at room temperature, 1mL per container every 2 days. For the water condition, on each watering day, we microwaved the water in the same way as we described above, allowed water to cool to room temperature before watering plants.

Measuring: We measured every three days. All measurements were recorded in a Microsoft Excel spreadsheet. We measured the height of the plant by using a measuring tape. We measured in cm. The first dependent variable was measuring from the soil to the tip of the plan by putting the measuring tape straight beside the grass and measuring the cm height (Figure 4). The second dependent variable was how many of the seeds grew out of the original three seeds in each container each day. The third dependent variable was the first day the plant grew out of the soil.

Figure 4. Measuring the plant length



Results and Analysis

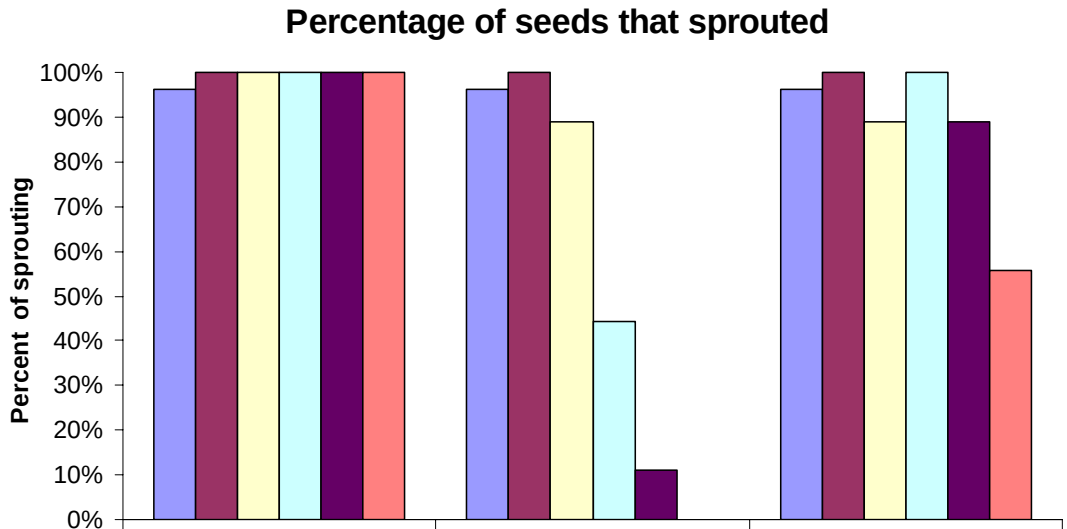


	Water	Seeds	Soil
Control	4.33	4.33	4.33
15s	3.67	3.33	4
30s	3.33	3	4
1min	2.33	5	3.33
2min	3	6	8
4min	3		6

Figure 5. This graph shows the day that the seeds first emerged.

In Figure 5, this graph shows the average day that each seed emerged from the soil. In the control for water, seed, and soil conditions, the result is the same because we combined data. The control was not treated with microwave, and the result is it took 4.33 days to emerge from the soil. For the water condition, the plants that were treated emerged more fast than the control. The one that emerged the fastest was the 1 minute-treated plant, which emerged an average of 2.33 days. For the seed condition, the seeds that were treated up to 30 seconds emerged faster than the control and the ones that were treated and 1 minute and above. The seeds that were treated for 4 minutes didn't grow at all. For the soil condition, the seeds that were in the 15 and 30 seconds microwaved took

4 days to emerge. The seeds that were in the container with the soil that was microwaved for 1 minute emerged in 3.33 days, which is the fastest to emerge in the soil condition. The seeds took longer to emerge in the soil that was microwaved for 2 and 4 minutes than the soil that was micrwaved for 1 minute or less.

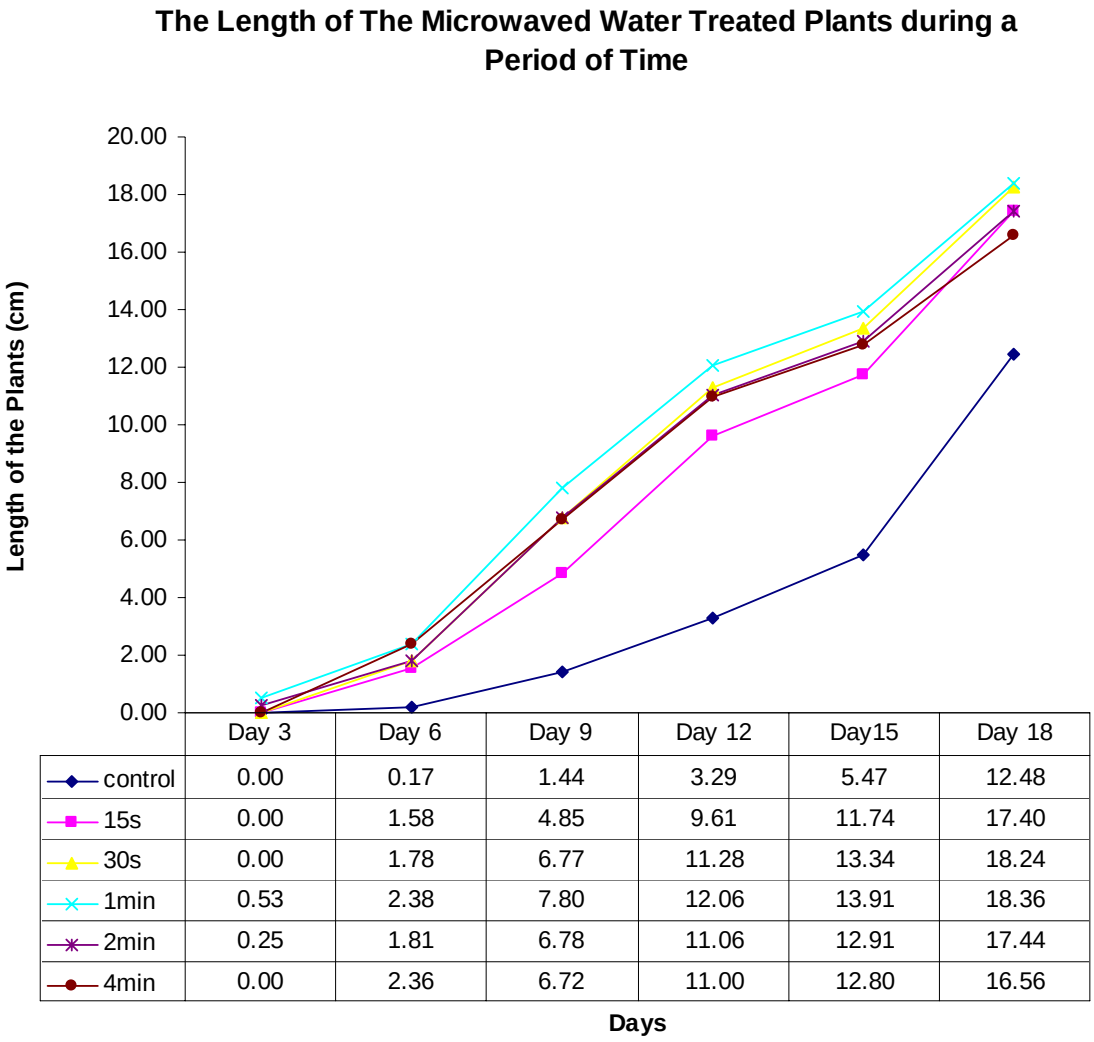


	Water	Seeds	Soil
Control	96%	96%	96%
15s	100%	100%	100%
30s	100%	89%	89%
1min	100%	44%	100%
2min	100%	11%	89%
4min	100%	0%	56%

Figure 6. This graph shows the percentage of seeds that sprouted.

The graph in Figure 6 shows the percentage of seeds that sprouted at all. The percentages for the control in the water, seed, and soil condition was combined together. The percentage that grew in the control was 96%. For the water condition, all of the plants that were treated grew. For the seed condition, the seeds that were treated for 15 seconds had a 100% chance of growing, and as the seeds were treated for 30 seconds or more, the seeds decreased in percentage of growth. At 4 minutes, the seeds did not grow

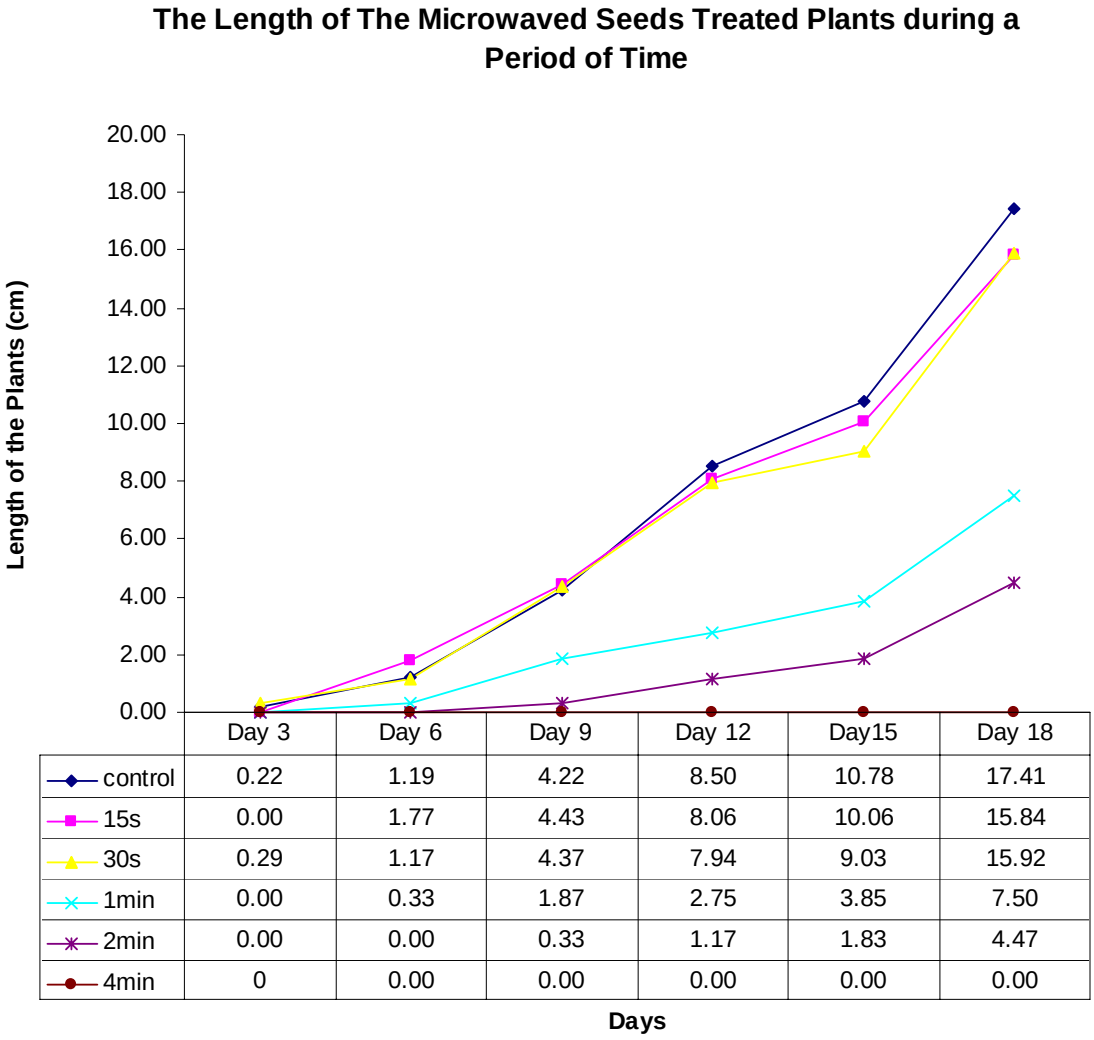
at all. For the soil condition, the microwave treatment did not have a clear affect, except for the 4 minute treatment, which was 56%.



	Day 3	Day 6	Day 9	Day 12	Day15	Day 18
control	0.00	0.17	1.44	3.29	5.47	12.48
15s	0.00	1.58	4.85	9.61	11.74	17.40
30s	0.00	1.78	6.77	11.28	13.34	18.24
1min	0.53	2.38	7.80	12.06	13.91	18.36
2min	0.25	1.81	6.78	11.06	12.91	17.44
4min	0.00	2.36	6.72	11.00	12.80	16.56

Figure 7. This graph shows the length of the plant that was treated with microwaved water.

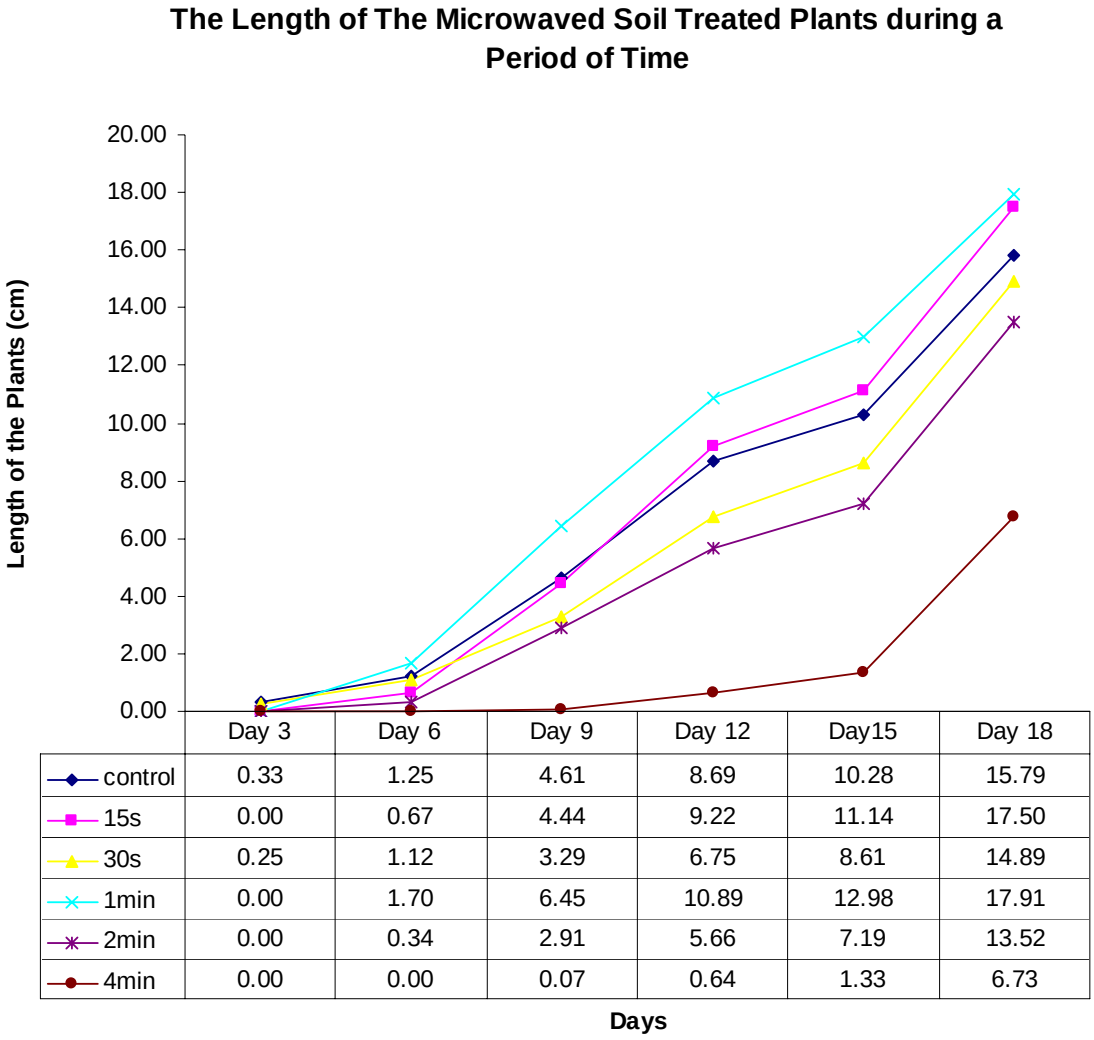
Figure 7 shows the length of the average plant that was treated with microwaved water during six measurements every three days. The control grew slower and did not grow more in length than the plants in the microwave treatmentments during measurements over 18 days. The plant that got microwaved water treatment for 1 minute grew more than all of the other plants.



	Day 3	Day 6	Day 9	Day 12	Day15	Day 18
control	0.22	1.19	4.22	8.50	10.78	17.41
15s	0.00	1.77	4.43	8.06	10.06	15.84
30s	0.29	1.17	4.37	7.94	9.03	15.92
1min	0.00	0.33	1.87	2.75	3.85	7.50
2min	0.00	0.00	0.33	1.17	1.83	4.47
4min	0	0.00	0.00	0.00	0.00	0.00

Figure 8. This graph shows the length of the plant that was treated microwaved seeds.

Figure 8 shows the length of the average plant that was treated with microwaved seeds during six measurements every three days. The control seeds started growing faster than the seeds treated with 1 minute and 2 minute microwaves. The control seeds grew similar to the seeds that were treated for 15 and 30 seconds. The more the seeds were microwaved, the length of the plant decreased. The seeds that were treated for 4 minutes of microwave didn't grow at all.



	Day 3	Day 6	Day 9	Day 12	Day15	Day 18
control	0.33	1.25	4.61	8.69	10.28	15.79
15s	0.00	0.67	4.44	9.22	11.14	17.50
30s	0.25	1.12	3.29	6.75	8.61	14.89
1min	0.00	1.70	6.45	10.89	12.98	17.91
2min	0.00	0.34	2.91	5.66	7.19	13.52
4min	0.00	0.00	0.07	0.64	1.33	6.73

Figure 9. This graph shows the length of the plants that the soil was microwaved.

Figure 9 shows the length of the average plant that was treated with microwaved soil during six measurements every three days. The plant that was in the 1 minute treated soil did not start growing the fastest on the first measurement at Day 3, but from day 6 through 18, it was the fastest to grow in length. The control started off the fastest on day 3, but ended up a lower length than the soil that was treated for 15 seconds and 1 minute.

The plant in the soil that was treated for 4 minutes had a big increase in length from day 15 to 18, but it was still the shortest in length for the soil that got treated with microwave.

Discussion and Conclusions

These experiments were designed to see if microwaving water, seeds, or soil would affect the growth of the plant. We used wheatgrass seeds in each container because they grow fast and provide results in a few weeks. We microwaved the water, seeds, and soil for different amounts of time starting at 15 seconds and doubling the time until four minutes. This gave us proper results because with more than one time, you can see the difference and compare the results to the control. We controlled everything except the time of microwaving the seeds, soil, and water, so the results will not change because of other factors. We made the Experimental Table (Figure 1) because it helps you keep the experiment organized and stop us from getting the containers out of place.

For the water condition, all the plants grew and microwaving made the plant grow faster and increased the length. For the seed condition, microwaving the seeds caused the plants to decrease in sprouting percentage, and as you increase the microwave time it decreases the length of the plant. For the soil condition, the length, the sprouting, and the day of first emergence wasn't constant and kept increasing and decreasing.

We identified some source error in our experiment that may or may not affect our result. The first error is the radiation was not the equal in all corners of the microwave oven, which means that the water, seeds, or soil could have got more radiation. In the future, we could microwave each seed, water, or soil individually in the same spot, microwave each closer to each other, or use microwave oven with a spinning plate to give

radiation from all around the oven. The second error is the soil in container labeled “F9” was burnt and didn’t absorb the water, and the seeds didn’t grow. The reason why this happened is because the soil was too hard for the seed to grow. The third error is that microwaving the water in a plastic cup could have had a different result because the plastic could have melted and the water could have pulled some chemical from the plastic. The chemical could have harmed the plant or make it grow better. In the future, we could use a glass cup instead of a plastic cup because it wouldn’t melt.

The data disproves our hypothesis but it also supports it. My hypothesis was that seeds would not grow the more you microwaved the soil, seeds, and water. This was partly because the more you microwave the soil and seeds, the seeds were more likely not to grow, and if they did grow, they didn’t grow as much as control. My hypothesis was not true because for the water condition, the more you microwave the water, the growth of the plant did increase. I think the results fully answer my research questions, which was if microwaves affect plant growth.

The next step is to research different types of microwave radiation like microwaves from cell phones, TV remote controls and antennas, computer signals, and signals from games. If signals from these things does affect plants, then we may have to use them less. If they affect plants, they could also affect any living things like humans, animals, etc. We’ll need research new things to put into cell phones or electronic devices that don’t expose to radiation.

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