Campus Educativo del Colegio María Auxiliadora
Carolina, Puerto Rico
Department of Sciences

Comparative study on the use of lunar regolith mixed with different types of substrates and the effect on the growth of spinach and tomato plants

Giants on the Moon – B
Team #20329
Students: Victoria Nolasco-González, Naihomy Hernández-Miranda, Yanaelis Conde-Llanos, Bryant Carmona-Quiñones, Paola García-Robles, Misael Álvarez-Torres, Carlos Cabrera-Rodríguez, Valeria Class-Rivera, Zashelle Martínez-Vargas, Vida Meléndez-Merced

Coach: Prof. Tiffany Rohena-Pérez
Plant the Moon Challenge Spring 2025

Background

First, in our experiment, we decided to choose spinach because it is a nutritious vegetable, rich in water, vitamins, and minerals (Huerto, 2023). We justified choosing spinach because we thought it would grow better and faster in the lunar regolith and the commercial soil with humic acid. Spinach is a plant full of vitamins and minerals (National Geographic, 2024). This plant helps various parts of our body, such as the heart, eyes, liver, and bones (National Geographic, 2024). We chose peat moss as an additive to the soil because it ensures good growth and is also good at retaining water and keeping the soil environment moist and saturated (Amazon, n.d.). Another additive we chose for the soil was humic acid because it absorbs nutrients and helps the plant grow (Jiménez, 2023). For the environment of the pots, we chose three types of LED lights: ultraviolet, white, and blue. We chose ultraviolet lights because they help plants grow in a variety of ways apart from their pH changing properties, for example, it can also improve the plants' flavor, color and overall quality (Zhang, 2024). We chose blue lights because they are ideal for plant germination and seedling growth (Erika, 2024). Finally, we chose white lights because they emulate natural sunlight (Ciki, & Ciki, 2023).

We decided to launch a second attempt on week 5 of the growing season. We kept the same amount of plant groups and growing pots but planted tomato seeds instead because they grow in full sun and are better suited for warm climates. They were planted with humic acid as well for nutrient absorption and root health. We decided to use commercial soil instead of peat moss to provide a more solid substrate for roots to grab onto as we noticed peat moss did not provide much stability to the spinach plants. It was determined that the ideal soil for tomato growth is sandy loam (Cherlinka, 2025). In this case, the mixture of commercial soil and lunar regolith is a good choice for sandy loam soil (Cherlinka, 2025). It is ideal because this type of soil drains well, and its pH is suitable for tomato cultivation (Cherlinka, 2025). The tomato is a fruit known for its health benefits (National Geographic, 2023). It is composed of 95% water, 4% carbohydrates, and less than 1% edible fats and proteins (National Geographic, 2023).

Some of the benefits of tomatoes include cancer prevention, protection of eyesight, skin, and hair, prevention of cardiovascular disease, and helping to regulate blood pressure (Tua Saúde, 2023). This time around, only 5 mL of purified water was added to avoid saturating the plant substrate as had happened with the spinach plants. It is suggested that tomatoes are sensitive to excess soil moisture and cannot tolerate soils with poor drainage and water filtration problems (UPR, 2016). Therefore, adequate soil moisture must be maintained throughout the crop's growth cycle (UPR, 2016). Due to the size of the seed, it can also suffer from poor waterlogging (UPR, 2016). Therefore, it is important and recommended to have an adequate amount of water, depending on the depth and the soil in which it is grown, (UPR, 2016). In this experiment we investigated the correct temperature for tomato cultivation to be 75°F to 85°F, similar to the temperature maintained in the plant growth room, with a humidity level between 65% and 85% (Cherlinka, 2025).

The goal of this project was to learn more about spinach and tomato plant growth in different recommended soils mixed with lunar regolith. In addition to this knowledge, our data contributes to NASA's ongoing research about the possibility of plant growth in the moon.

Experimental design

To be able to plant the spinach plants and test our first hypothesis, the following materials we used: iPower LED Strips Full Spectrum for Indoor Plants (4 tubes), pots with drainage holes and labels (15 pots), 10mL syringes (5 syringes), 4-in-1 Digital PH Meter/Soil Moisture/Plant Temperature/Sunlight Intensity, Small Digital Gram Scale 1000g by 0.01g, Spinach Bloomsdale seeds, Gove Hygrometer Thermometer H5075, BIOAG Ful-Humix Organic Humic Acid Soil Dry Amendment, Sphagnum Peat Moss (w/ peat moss, rice charcoal, coco coir, perlite, and vermiculite), and purified water. Our growing pot setup included two control groups and three experimental groups; each group will have three replicas. In our spinach grow pot setup, the two control groups had 100% lunar regolith and 100% commercial soil, respectively. The experimental groups had the following soil mixtures: Experimental Group A had 90% lunar regolith and 10% peat moss; Experimental Group B had 75% lunar regolith and 25% peat moss; Experimental Group C had 50% lunar regolith and 50% peat moss. All the plant groups received 2g of humic acid as soil amendments. We planted two spinach seeds per growing pot. We provided spinach seeds and plants with 12-hour LED light cycles alternating between ultraviolet lights (7 days), blue lights (12 days) and white lights (14 days). We also added purified water irrigation that was adjusted depending on soil humidity starting with 10 mL and reducing throughout the experiment.

To test our second hypothesis with the tomato plants, the following materials were used: iPower LED Strips Full Spectrum for Indoor Plants (4 tubes), pots with drainage holes and labels (15 pots), 10mL syringes (5 syringes), 4-in-1 Digital PH Meter/Soil Moisture/Plant Temperature/Sunlight Intensity, Small Digital Gram Scale 1000g by 0.01g, Tomato Bloomsdale seeds, Gove Hygrometer Thermometer H5075, BIOAG Ful-Humix Organic Humic Acid Soil Dry Amendment, Vigoro All-purpose potting mix (commercial soil), and purified water. When we started planting, students were ordered to wear gloves and masks to prevent situations. Each tomato seed was planted at a soil depth of approximately 1.27 cm. There were also two control groups and three experimental groups with three replicas per plant group. In our control groups we had Control Group A with 100% lunar regolith and Control Group B with 100% commercial soil. In the experimental groups we had the following mixtures: Experimental Group A had 90% lunar regolith and 10% peat moss; Experimental Group B had 75% lunar regolith and 25% peat moss; Experimental Group C had 50% lunar regolith and 50% peat moss. All the plant groups had 1g of humic acid as soil amendments. We provided tomato seeds and plants with 12-hour cycles of white LED lights (23 days). We also added purified water irrigation to each pot depending on soil humidity starting with 5 mL instead.

Figure 1. Experimental design arrangement for the spinach plants.

Grow pot setup				
Control A	Control B	Experimental A	Experimental B	Experimental C
100% Lunar regolith (375g) +2g humic acid	100% Peat moss (90g) +2g humic acid	90% Lunar regolith (337.5g) + 10% Peat moss (33.75g) +2g humic acid	75% Lunar regolith (142.5g) + 25% Peat moss (47.5g) +2g humic acid	50% Lunar regolith (60g) + 50% Peat moss (60g) +2g humic acid
Two spinach seeds per growing pot 12-hour LED light cycles alternating between ultraviolet lights (7 days), blue lights (12 days) and white lights (14 days) Purified water irrigation adjusted depending on soil humidity				

Figure 2. Experimental design arrangement for the tomato plants.

Grow pot setup				
Control A	Control B	Experimental A	Experimental B	Experimental C
100% Lunar regolith (262.5g) +1g humic acid	100% Commercial soil (150g) +1g humic acid	90% Lunar regolith + 10% Commercial soil (337.5g + 37.5g) +1g humic acid	75% Lunar regolith + 25% Commercial soil (281.25g + 93.75g) +1g humic acid	50% Lunar regolith + 50% Commercial soil (112.5g each) +1g humic acid
One tomato seed per growing pot 12-hour LED white light cycle (23 days) Purified water irrigation adjusted depending on soil humidity				

Hypothesis

If we apply various ingredients to a spinach plant, which would be peat moss, (containing rice charcoal, coco coir, perlite, and vermiculite as well), organic humic acid, lunar regolith and different types of lights (ultraviolet, red, and white lights), then the growth of the spinach would increase. Peat moss helps to maintain soil pH constant. This soil additive keeps the plant hydrated and ensures nutrient retention within its soil. Since peat moss is an ideal fertilizer for hydration and spinach is a plant that requires hydrated soil, peat could be added at 10% to 50% the total amount of soil. These quantities would help spinach grow in lunar regolith, which does not have nutrients.

If we apply several ingredients to a tomato plant, such as commercial soil, organic humic acid, lunar regolith (lunar soil), and white LED lights, tomato growth will increase. Applying humic acid to the tomato plant stimulates vertical growth, resulting in healthier, more robust plants. It also improves leaf production, which is crucial for efficient photosynthesis and overall plant vigor. White light provides a better growth environment for plants. These ingredients help the tomato plant grow in lunar regolith, which lacks nutrients.

The main questions of our research project are:

→ How will lunar regolith affect the growth of our spinach and tomato plants, since they are not typically grown in lunar regolith?
→ How much peat moss and commercial soil should be added to the lunar regolith to promote spinach and tomato plant growth?
→ What benefits will humic acid provide when applied to the spinach and tomato plants?

Independent variables

Our independent variable that serves as the core of this experiment is the amount of regolith that was used to grow both spinach and tomato plants. Our first control group identified as Control A, contained 100% lunar regolith. The second control group, identified as Control B, contained 100% peat moss for the spinach plants and 100% commercial soil for the tomato plants. As for the experimental groups, identified as Experimental A, Experimental B, and Experimental C, they contained ratios of 90%, 75% and 50% lunar regolith mixed with 10%, 25% and 50% peat moss or commercial soil, respectively.

Dependent variables

The dependent variable of this study was the growth of both the spinach and tomato plants which was determined by primarily by plant height in centimeters, weekly pot mass changes, and number of plant leaves. At the end of the experiment, we were able to include harvested plant mass and root length growth measurements for the tomato plants that grew.

Measurements and procedures

We took seven types of measurements. We performed these weekly and daily. The weekly measurements, done every Sunday, included: soil pH, plant growth in centimeters, leaf number, pot mass, soil temperature and soil humidity of each pot. Before taking all these measurements, each pot was watered according to its needs. Every day, we measured room temperature and humidity. During the second experiment with the tomato plants, we changed to measuring the weekly pot mass every Friday and included the last day of the growing season as well, which was Sunday, March 30th, 2025. We recorded all these measurements in a laboratory notebook and transcribed the data to an Excel Spreadsheet.

Controls

When sowing spinach and tomato seeds, the amount of humic acid, type of lights and duration, type of pots, number of seeds, and room environment remained the same for all growing pots, except for the amount of water irrigation, as this depended greatly on soil humidity. When the experiment was restarted with the tomato seeds, the amount of humic acid was changed to 1 g instead of 2 g, commercial soil was used instead of peat moss and one seed was sown in each pot instead of two.

Results

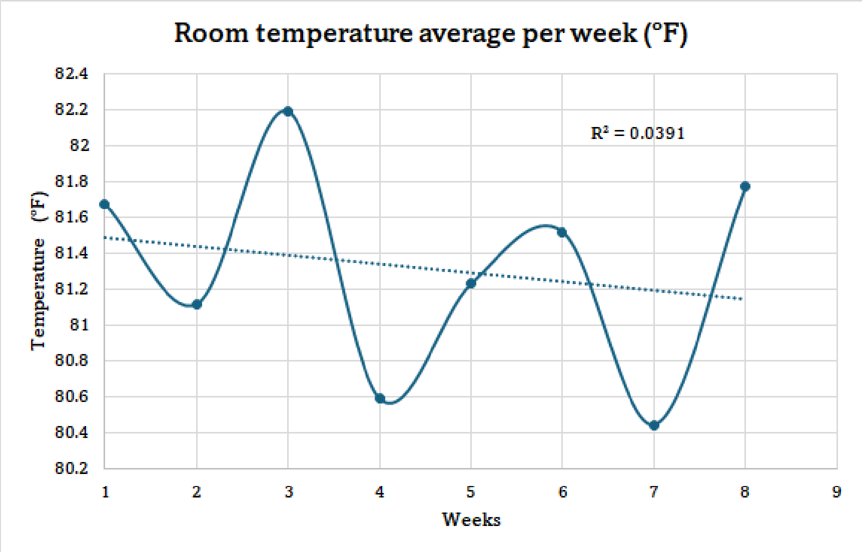


Figure 3. This graph shows that temperature remained relatively persistent over the 56 days, demonstrating that the environment was under control.

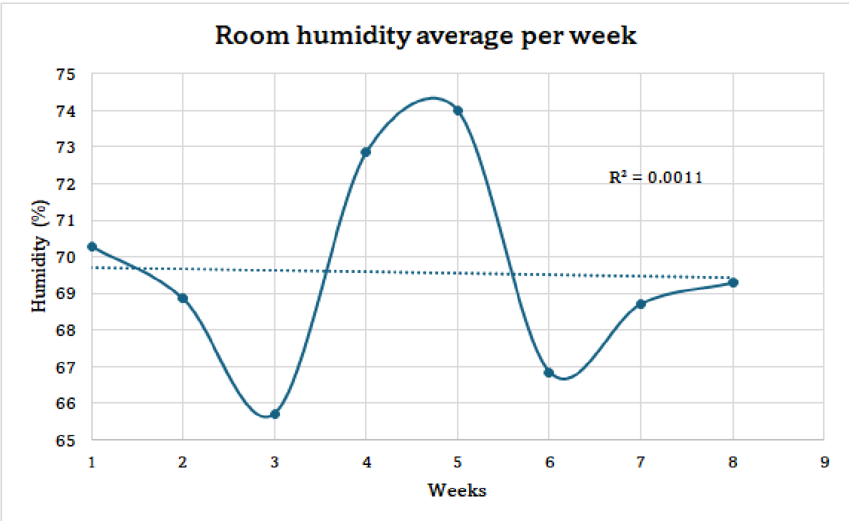


Figure 4. This graph shows that humidity remained relatively persistent over the 56 days, demonstrating that the environment was under control.

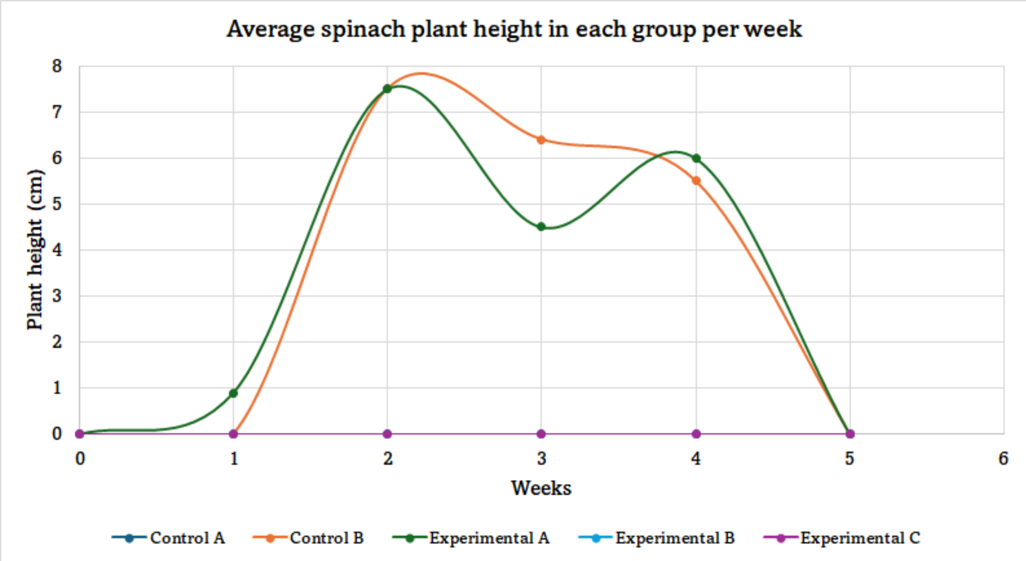


Figure 5. This graph shows that the spinach Control Group B was the group with the greatest growth. Control Group A and Experimental Groups B and C showed no growth.

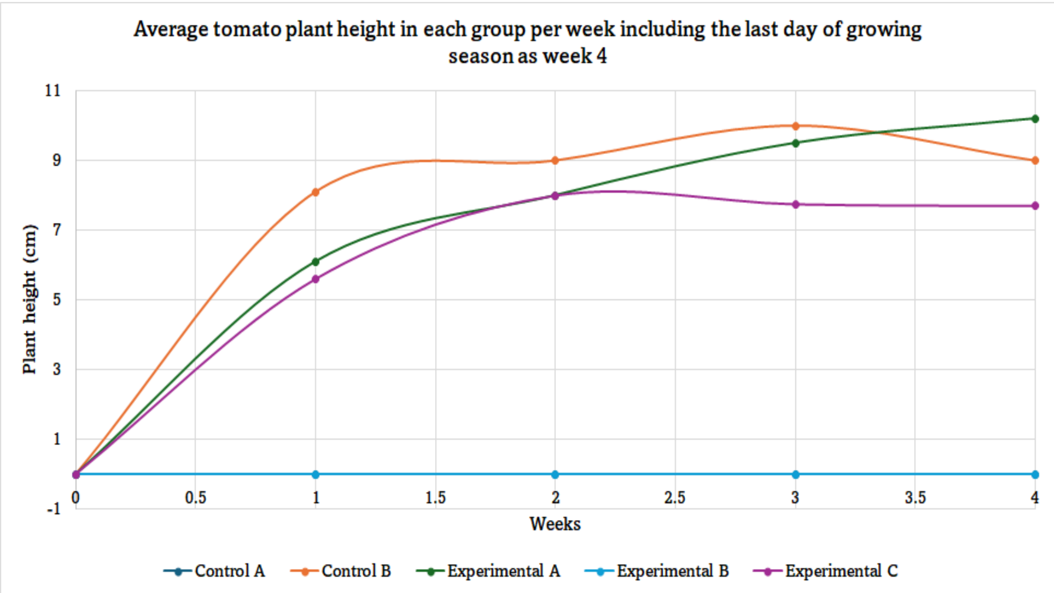


Figure 6. This graph shows that the tomato Experimental Group A was the group with the highest plant growth and that Control Group A and Experimental B had zero growth.

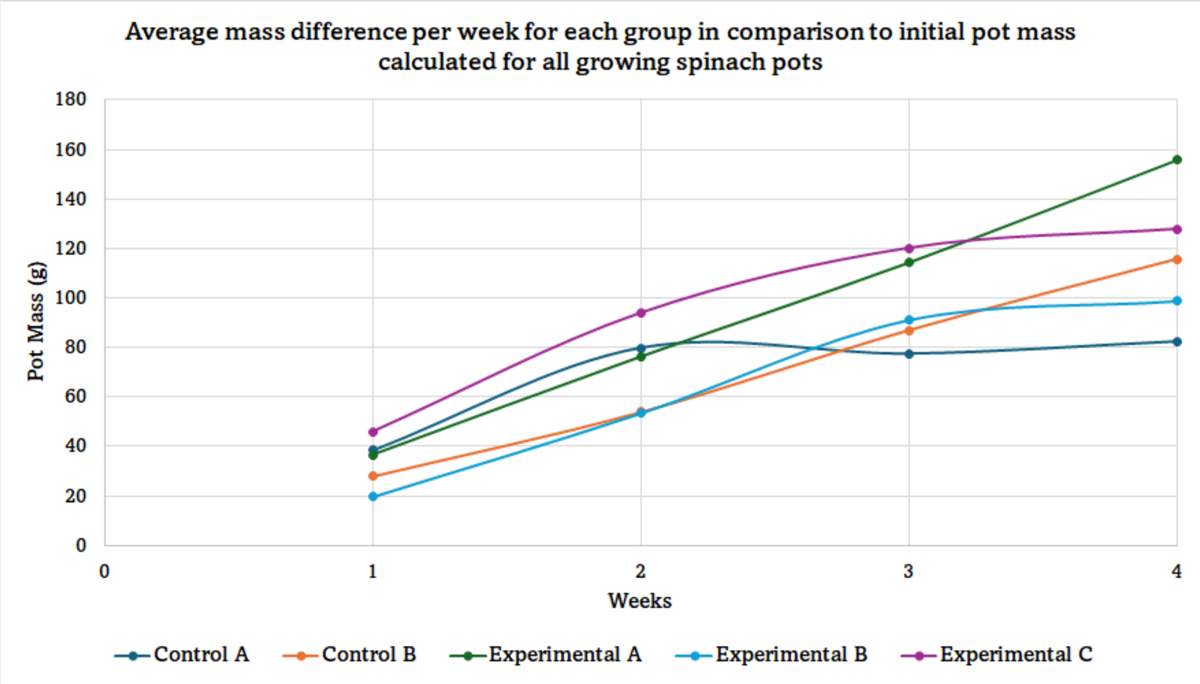


Figure 7. This graph shows that spinach Experimental Group A had the highest average mass of pots. Experimental Group B had the lowest average mass.

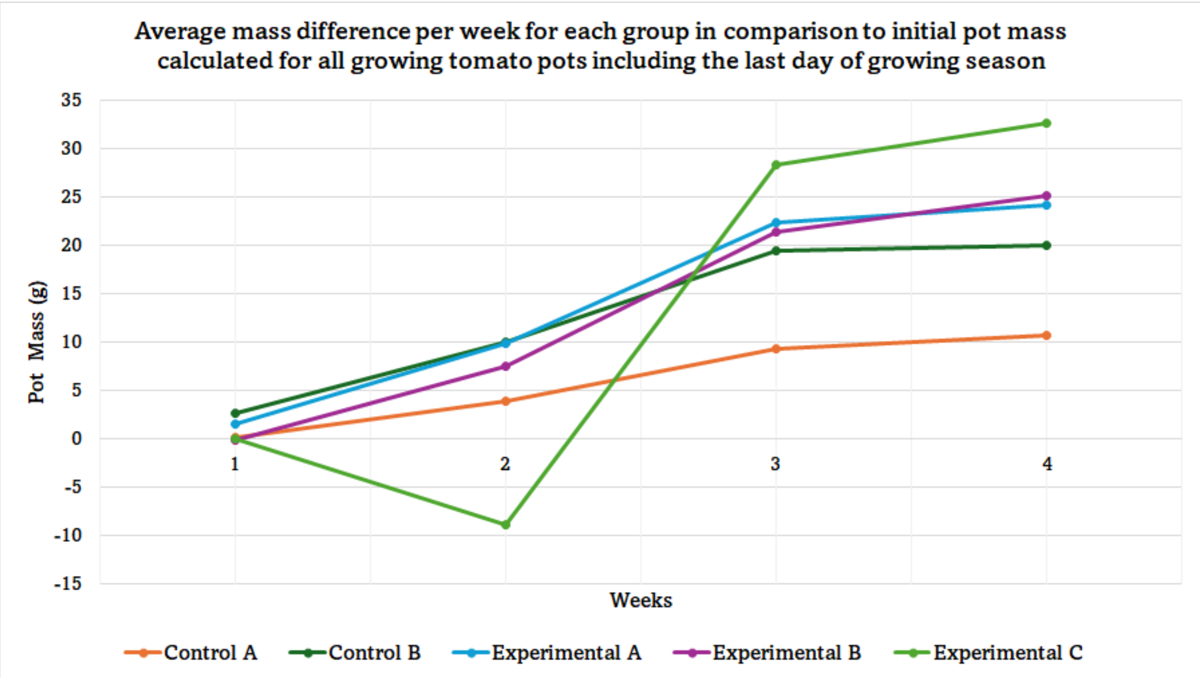


Figure 8. This graph shows that the tomato Experimental Group C had the highest average pot mass. The Experimental Group C had the lowest average pot mass in week two.

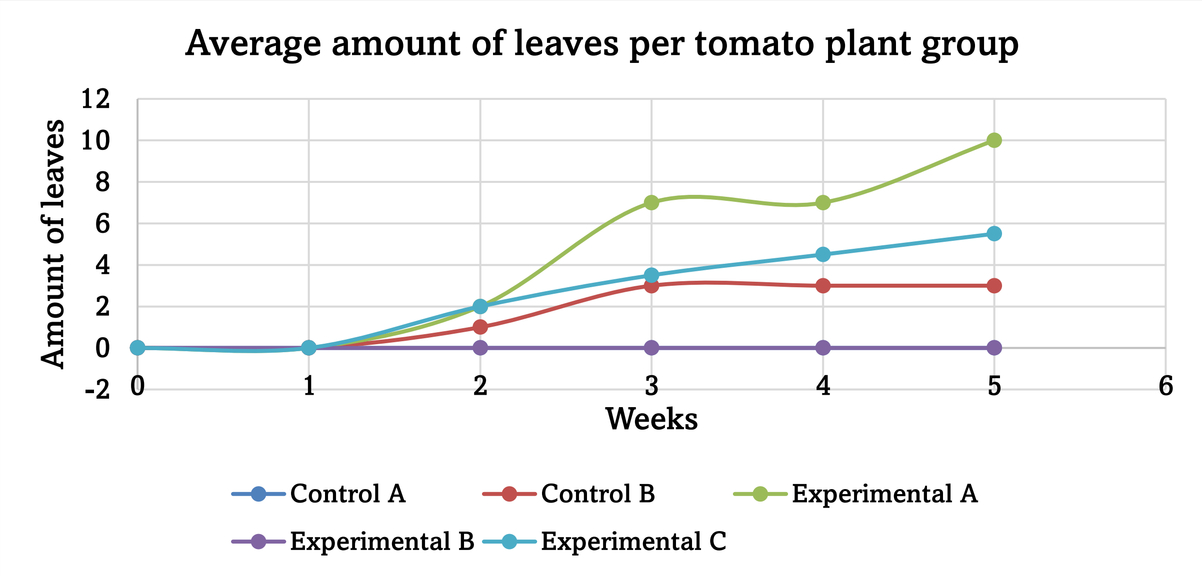


Figure 9. This graph shows that the tomato Experimental Group A had the highest number of leaves per plant. Control Group A and Experimental Group B had no plant growth.

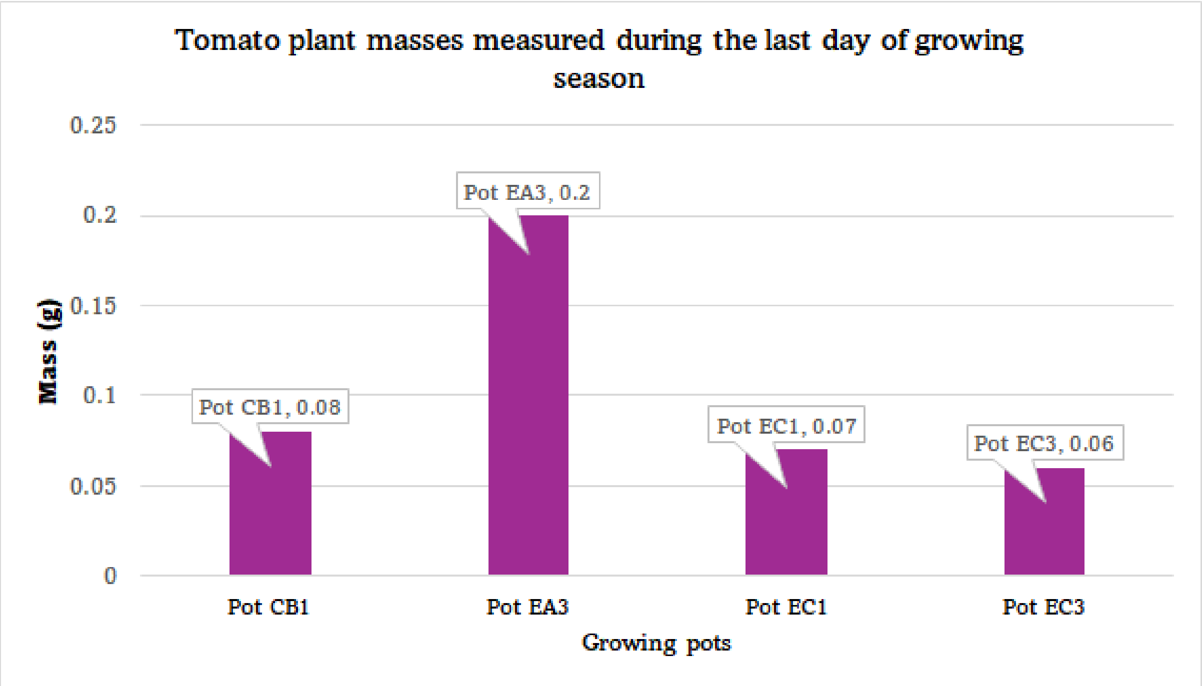


Figure 10. This graph shows that the tomato Experimental Pot A #3 obtained the highest plant mass while the lowest was the Experimental Pot C #3 from the plants that grew.

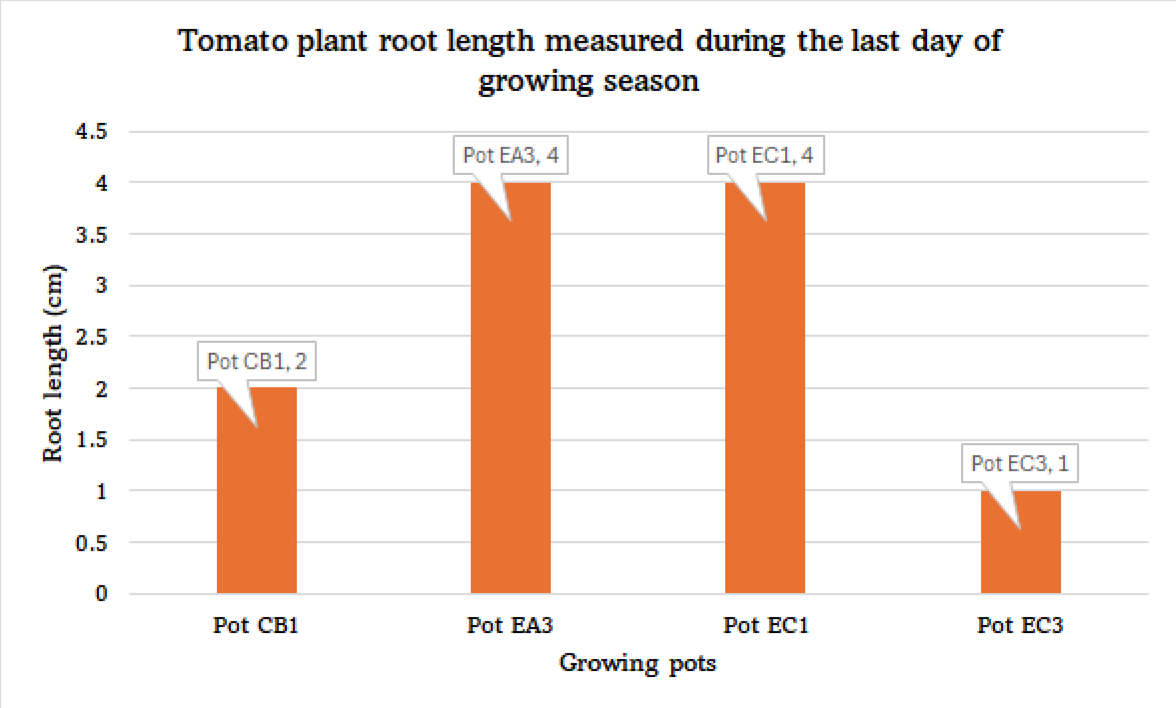


Figure 11. This graph shows that the highest average of tomato root length was found in the Experimental Pot A #3 and the Experimental Pot C #1. The lowest average was Experimental Pot C #3.

The results of the spinach plants did not turn out as we hypothetically expected. The plants did not grow at first, but later three plants grew. The spinach plants that grew were not able to survive beyond two weeks mainly due to being overwatered, while the rest of the growing pots showed no growth at all. We noticed that the sowing information included in the spinach seed packet explained that this seed is best planted in a cold climate. We believe this to be the main reason the spinach plants did not grow properly. On the other hand, four out of fifteen tomato plants managed to grow. We observed the growth of these four plants within the first week and continued to increase positively for the rest of the growing season. No plants grew in the control pot that contained 100% regolith. On the graphs of average weekly tomato pot mass difference, we encountered negative results that we believe are due to the reduction in the amount of water irrigation after planting the tomato seeds. The graphs show the averages for each of the groups of potsherds. The highest and lowest averages for each week in progress are shown.

Discussion and conclusions

The spinach plants could not grow properly because they are recommended to be sown in a cold climate. This first experience with the spinach plants brought awareness regarding the method of water irrigation we were using, and we were able to modify our approach to prevent the tomato plants from being saturated. A few parameters were changed in this new attempt, such as: 1 g of humic acid, 5 mL of purified water, and commercial soil instead of peat moss.

Only white light was used. This new approach went well, as the tomato plant seeds sown were already growing within the first week and began to sprout leaves during the first and second weeks. The spinach hypothesis was accepted since the aggregates in the soil did have an influence on plant growth, but most did not persist. Since the spinach plants are too susceptible to environmental changes and need such a specific environment to grow properly, we recommend considering other plants to plant on the moon instead. For instance, as the tomato hypothesis was accepted and the plants persisted continuing to grow, tomatoes would be better suited to plant in the moon than spinach plants. The tomato plant has many benefits, and it has already been observed that with some additions, it could have growth in the lunar regolith. Specifically, the tomato plant shows good growth correspondence with the lunar soil combined with humic acid and commercial soil plus it can cope better with different growing environments, so astronauts could have a great option with the tomato on the moon.

Based on the results, some factors contributed negatively to our experiment such as the depth at which the spinach seed was sown and the amount of water that was added to each pot. On the other hand, we observed positive factors that influenced the growth of both spinach and tomato, such as the humic acid for its improvement in the roots of the plants and other benefits (Tecnologia Horticola, 2023) and the usage of 12-hour cycle LED lights. For a future experiment, we would improve the measurement techniques to ensure proper data collection, adjust the amount of water for each pot since the beginning according to soil humidity, ensure a proper seed sowing depth, and research more thoroughly the needs of the types of seeds to create an adequate experimental design that yields higher plant growth (plant height, number of leaves and plant mass).

Annexes

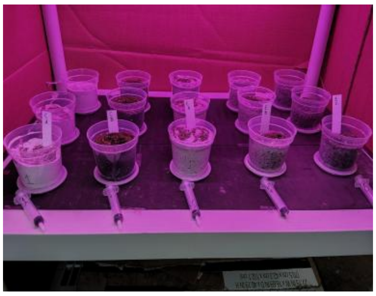
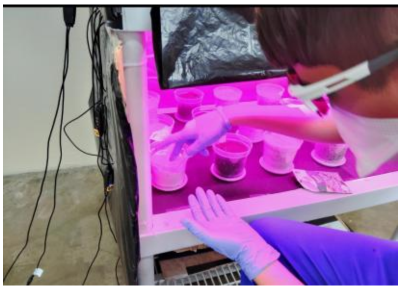
Pictures

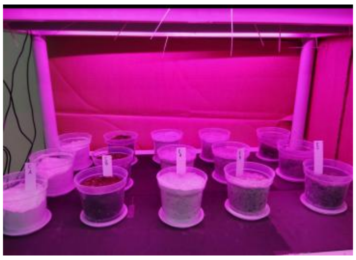
30-January-2025



Pot soil was prepared for all plant groups. The pictures above show regolith and humic acid being applied to CA1, CA2 and CA3 pots.

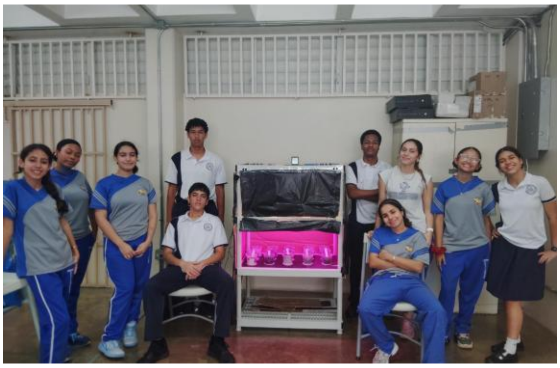
3-February-2025



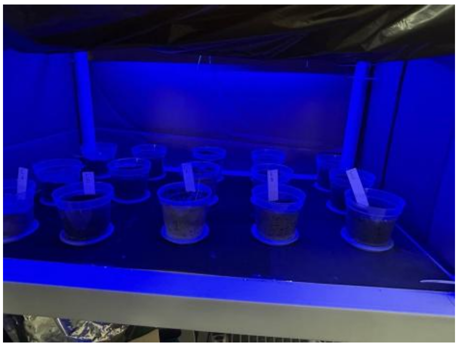
The experiment began and we planted two spinach seeds in each pot.

5-February-2025



We took the group photo and poured water into the pots.

11- February-2025



10 mL of purified water was added with a syringe.

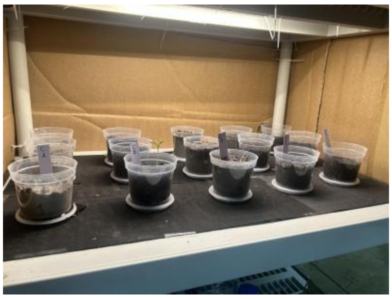
17- February- 2025

The pots were ready with 5 ml drops of water with a daily syringe..

19-February-2025

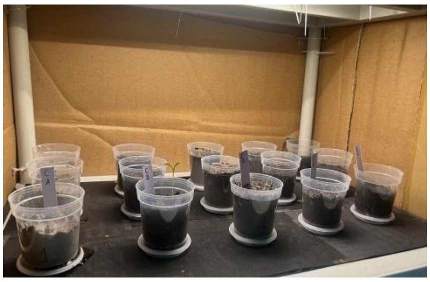
The growing pots received 5 mL of daily water with a syringe.

25-February-2025

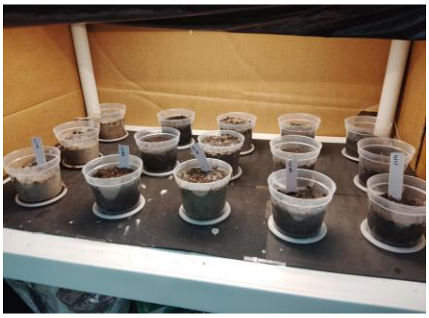


The growing pots received 5 mL of water daily with a syringe. The growth pot setup included white LED lights that worked in a 12-hour cycle from the 25th of February until the 8th of March.

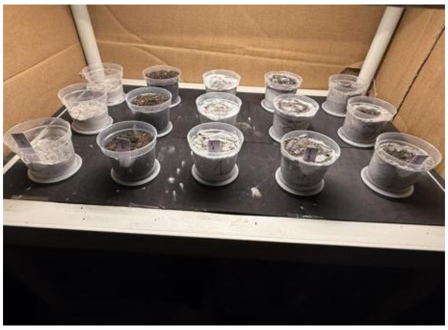
1-March-2025

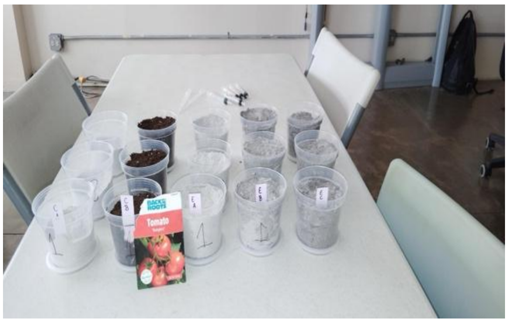


5-March-2025



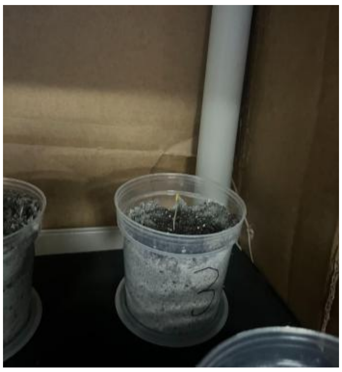
8-March-2025





The new growing pots are set with one tomato seed in each growing pot. All the tomato seeds received 5 mL of daily water with a syringe. The growth pot setup included white LED lights that worked in a 12-hour cycle from the 8th of March until the 30th of March.

13- March-2025

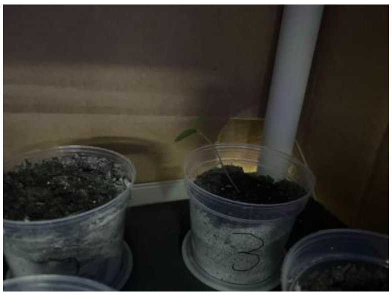


The growing pots received 5 mL of daily water with a syringe. We had two tomato seeds that sprouted into plants.

16-March-2025

The growing pots received 5 mL of daily water with a syringe. We had four tomato seeds that sprouted into plants.

19-March-2025

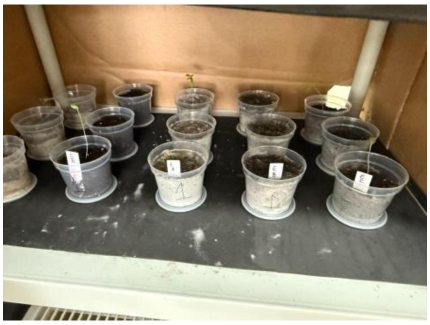


The growing pots received 5 mL of daily water with a syringe. The tomato plants continue to grow.

20-March-2025

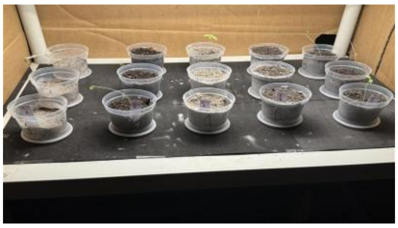
22-March-2025

23-March-2025

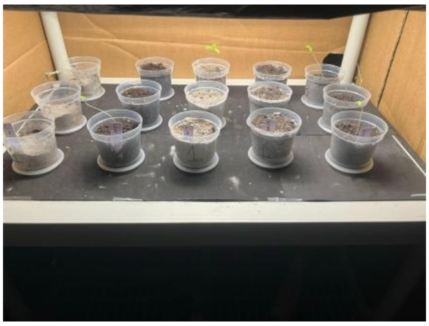


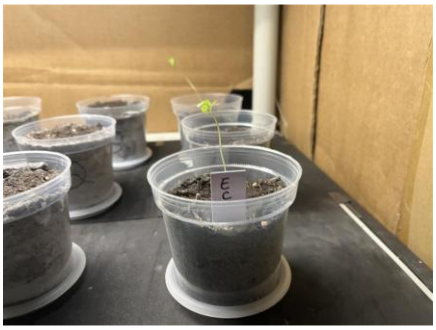
24-March-2025

25-March-2025

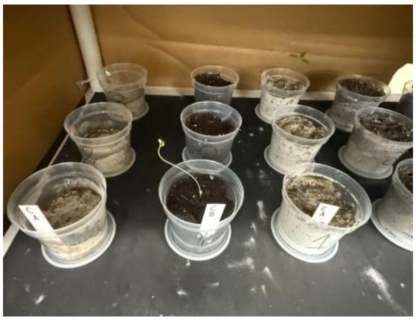


27-March-2025

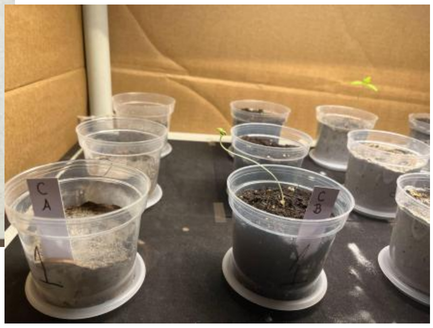




28-March-2025



30-March-2025



On this last day, the soil pH, soil temperature, and soil humidity were measured as well as plant height, pot mass and number of leaves. Only pots CB1, EA3, EC1 and EC3 grew tomato plants, thus their root length plus harvested plant mass was also measured.

Tables

Table 1. Weekly pot mass measurements for the spinach growing pots.

Spinach Pots	*Initial Pot Mass Spinach (g)*	*Week 1 Pot Mass (g)*	*Week 2 Pot Mass (g)*	*Week 3 Pot Mass (g)*	*Week 4 Pot Mass (g)*
CA1	417.79	456.77	497.23	491.91	493.18
CA2	417.34	457.65	499.56	490.48	496
CA3	417.79	453.47	495.37	502.87	510.66
CB1	118.82	140.21	165.47	197.95	215.4
CB2	117.22	148.44	174.59	207.26	246.72
CB3	118.82	150.36	176.58	210.23	239.29
EA1	401.65	436.49	472.4	514.79	545.08
EA2	401.19	438.75	484.96	519.05	568.72
EA3	398.73	436.12	473.22	510.75	555.19
EB1	222.1	241.69	274.8	309.41	340
EB2	221.42	241.56	276.17	315.43	311.43
EB3	221.41	240.61	274.25	313.59	310
EC1	152.26	194.23	237.96	263.07	267.34
EC2	151.04	204.03	248.56	275.66	275.99
EC3	150.63	193.71	249.16	275.61	293.93

Table 2. Weekly pot mass difference compared to initial pot mass for the spinach growing pots.

Spinach Pots	*Pot Mass Difference Week 1*	*Pot Mass Difference Week 2*	*Pot Mass Difference Week 3*	*Pot Mass Difference Week 4*
CA1	38.98	79.44	74.12	75.39
CA2	40.31	82.22	73.14	78.66
CA3	35.68	77.58	85.08	92.87

CB1	21.39	46.65	79.13	96.58
CB2	31.22	57.37	90.04	129.5
CB3	31.54	57.76	91.41	120.47
EA1	34.84	70.75	113.14	143.43
EA2	37.56	83.77	117.86	167.53
EA3	37.39	74.49	112.02	156.46
EB1	19.59	52.7	87.31	117.9
EB2	20.14	54.75	94.01	90.01
EB3	19.2	52.84	92.18	88.59
EC1	41.97	85.7	110.81	115.08
EC2	52.99	97.52	124.62	124.95
EC3	43.08	98.53	124.98	143.3

Table 3. Weekly pot mass difference average for each spinach plant group.

Spinach Group	*Average Pot Mass Week 1*	*Average Pot Mass Week 2*	*Average Pot Mass Week 3*	*Average Pot Mass Week 4*
Control A	38.32333333	79.74666667	77.44666667	82.30666667
Control B	28.05	53.92666667	86.86	115.5166667
Experimental A	36.59666667	76.33666667	114.34	155.8066667
Experimental B	19.64333333	53.43	91.16666667	98.83333333
Experimental C	46.01333333	93.91666667	120.1366667	127.7766667

Table 4. Weekly pot mass measurements for the tomato growing pots.

Tomato Pots	*Inicial Pot Mass Tomato (g)*	*Week 1 Pot Mass (g)*	*Week 2 Pot Mass (g)*	*Week 3 Pot Mass (g)*	*Last day Pot Mass (g)*
CA1	309.5	307.78	311.51	317.84	319.14
CA2	304.48	306.3	310	313.62	316.01
CA3	305.95	306.22	310	316.17	317.22
CB1	188.18	191.45	194.85	200	202.01
CB2	187.62	190.23	194.25	198.86	200
CB3	187.9	189.44	193.18	195.53	197.16
EA1	415.65	415.22	416.62	420	420.47
EA2	414.51	412.03	413.1	416.29	417.01
EA3	413.09	412.92	413.1	415.59	415.1
EB1	414.93	415.12	415.32	417.42	416.44
EB2	414.86	411.84	409.25	411.19	412
EB3	415.73	413.34	413.53	413.97	414.47
EC1	264.65	263.66	210	272.31	272.43
EC2	264.33	266.45	268.31	271.02	272.73

EC3	264.09	263.66	265.98	270.72	271.27

Table 5. Weekly pot mass difference compared to initial pot mass for the tomato growing pots.

Tomato Pots	*Pot Mass Difference Week 1*	*Pot Mass Difference Week 2*	*Pot Mass Difference Week 3*	*Pot Mass Difference Last Day*
CA1	-1.72	2.01	8.34	11.36
CA2	1.82	5.52	9.14	9.71
CA3	0.27	4.05	10.22	11
CB1	3.27	6.67	11.82	10.56
CB2	2.61	6.63	11.24	9.77
CB3	1.54	5.28	7.63	7.72
EA1	-0.43	0.97	4.35	5.25
EA2	-2.48	-1.41	1.78	4.98
EA3	-0.17	0.01	2.5	2.18
EB1	0.19	0.39	2.49	1.32
EB2	-3.02	-5.61	-3.67	0.16
EB3	-2.39	-2.2	-1.76	1.13
EC1	-0.99	-54.65	7.66	8.77
EC2	2.12	3.98	6.69	6.28
EC3	-0.43	1.89	6.63	7.61

Table 6. Weekly pot mass difference average for each spinach plant group.

Tomato Group	*Average Pot Mass Week 1*	*Average Pot Mass Week 2*	*Average Pot Mass Week 3*	*Average Pot Mass Week 4*
Control A	0.123333333	3.86	9.233333333	10.69
Control B	2.473333333	6.193333333	10.23	9.35
Experimental A	-1.026666667	-0.143333333	2.876666667	4.136666667
Experimental B	-1.74	-2.473333333	-0.98	0.87
Experimental C	0.233333333	-16.26	6.993333333	7.553333333

Table 7. Weekly plant height measurements for the spinach growing pots.

Spinach Pots	Plant Height Week 1 (cm)	Plant Height Week 2 (cm)	Plant Height Week 3 (cm)	Plant Height Week 4 (cm)
CA1	0	0	0	0
CA2	0	0	0	0

CA3	0	0	0	0
CB1	0	0	6.4	5.5
CB2	0	0	0	0
CB3	0	7.5	0	0
EA1	0.9	7.5	4.5	6
EA2	0	0	0	0
EA3	0	0	0	0
EB1	0	0	0	0
EB2	0	0	0	0
EB3	0	0	0	0
EC1	0	0	0	0
EC2	0	0	0	0
EC3	0	0	0	0

Table 8. Weekly plant height average for each spinach plant group.

Spinach Group	Plant Height Average Day 1 (cm)	Plant Height Average Week 1 (cm)	Plant Height Average Week 2 (cm)	Plant Height Average Week 3(cm)	Plant Height Average Week 4 (cm)	Plant Height Average Week 5 (cm)
Control A	0	0	0	0	0	0
Control B	0	0	7.5	6.4	5.5	0
Experimental A	0	0.9	7.5	4.5	6	0
Experimental B	0	0	0	0	0	0

Experimental C	0	0	0	0	0	0

Table 9. Weekly plant height measurements for the tomato growing pots.

Tomato Pots	Plant Height Week 1 (cm) March 14th, 2025	Plant Height Week 2 (cm)	Plant Height Week 3 (cm)	Plant Height Last Day (cm) March 30th, 2025
CA1	0	0	0	0
CA2	0	0	0	0
CA3	0	0	0	0
CB1	8.1	9	10	9
CB2	0	0	0	0
CB3	0	0	0	0
EA1	0	0	0	0
EA2	0	0	0	0
EA3	6.1	8	9.5	10.2
EB1	0	0	0	0
EB2	0	0	0	0
EB3	0	0	0	0
EC1	5.1	7	6.5	6.7
EC2	0	0	0	0
EC3	6.1	9	9	8.7

Table 10. Weekly plant height average for each tomato plant group.

Tomato Group	Plant Height Average Day 1 (cm) March 8th, 2025	Plant Height Average Week 1 (cm)	Plant Height Average Week 2 (cm)	Plant Height Average Week 3 (cm)	Plant Height Average Last Day (cm) March 30th, 2025
Control A	0	0	0	0	0
Control B	0	8.1	9	10	9
Experimental A	0	6.1	8	9.5	10.2

Experimental B	0	0	0	0	0
Experimental C	0	5.6	8	7.75	7.7

Table 11. Weekly number of leaves for each tomato plant.

Tomato Pots	Number of leaves on Day 1 March 8th, 2025	Number of leaves Week 1 March 14th, 2025	Number of leaves Week 2 March 21st, 2025	Number of leaves Week 3 March 28th, 2025	Number of leaves Last Day March 30th, 2025
CA1	0	0	0	0	0
CA2	0	0	0	0	0
CA3	0	0	0	0	0
CB1	0	1	3	3	3
CB2	0	0	0	0	0
CB3	0	0	0	0	0
EA1	0	0	0	0	0
EA2	0	2	0	0	0
EA3	0	0	7	7	10
EB1	0	0	0	0	0
EB2	0	0	0	0	0
EB3	0	0	0	0	0
EC1	0	2	3	4	5
EC2	0	0	0	0	0
EC3	0	2	4	5	6

Table 12. Weekly average number of leaves for each tomato plant group.

Group	Number of leaves Day 1	Average number of leaves Week 1 March 14th, 2025	Average number of leaves Week 2 March 21st, 2025	Average number of leaves Week 3 March 28th, 2025	Average number of leaves Last Day March 30th, 2025
Control A	0	0	0	0	3
Control B	0	1	3	3	10

Experimental A	0	2	7	7	0
Experimental B	0	0	0	0	5.5
Experimental C	0	2	3.5	4.5	0

Table 13. Harvested tomato plant mass and root length measured for the successfully grown plants on March 30th, 2025.

Tomato Plants	Plant Mass (g)	Root Length (cm)
Pot CB1	0.08	2
Pot EA3	0.2	4
Pot EC1	0.07	4
Pot EC3	0.06	1

Table 14. Daily measurements of room temperature and humidity.

Day	Room temperature (ºF)	Room Humidity (%)
1	82.2	73
2	82.1	66
3	82.3	67
4	82.7	65
5	82.1	70
6	80.4	76
7	79.9	75
8	82.3	74
9	82.1	64
10	81.8	67

11	81.3	70
12	79.6	72
13	77.9	76
14	82.8	59
15	82.2	63
16	82.8	59
17	83.4	67
18	84	62
19	83.1	63
20	80.4	73
21	79.4	73
22	81.9	64
23	80.7	79
24	79.8	79
25	81.2	70
26	80.6	72
27	80.2	75
28	79.7	71
29	81.1	76

30	80.1	77
31	80.4	74
32	81.9	70
33	81.8	76
34	81.1	74
35	82.2	71
36	82.9	68
37	83.9	52
38	82.8	64
39	83	68
40	80.6	74
41	78.4	73
42	79	69
43	80.6	64
44	82.3	63
45	80.3	65
46	80.1	60
47	80.3	71
48	80	76

49	79.5	82
50	81.7	63
51	81.4	76
52	82	68
53	83.4	63
54	81.5	69
55	81.6	74
56	80.8	72

References

Actagro. (n.d.). *Humic Acid 10% General Information*. Retrieved from https://www.actagro.com/wp-content/uploads/2017/12/Humic-Acid-10.pdf

Application rates — The Plant's Choice. (n.d.). The Plant's Choice. Retrieved April 10, 2025, from https://www.theplantschoice.com/application-rates

Barboza, A., & Gago, J. (2023, August 25). Understanding light spectrum for plant growth: How different LED lights affect growth stages. Grow Light Reviews. https://www.growlightreviews.com/understanding-light-spectrum-plant-growth

Brady, C. (2025, March 23). *Soil secrets for healthy tomato plants*. Shuncy.com; ShunCy. https://shuncy.com/article/what-kind-of-soil-do-you-use-to-plant-tomatoes

Can white LED lights grow plants. (2023, August 29). *Spider Farmer UK - Spider Farmer UK Official Website*. https://spiderfarmer-co-uk.translate.goog/2023/08/29/can-white-led-lights-grow-plants/?_x_tr_sl=en&_x_tr_tl=es&_x_tr_hl=es&_x_tr_pto=rq

Cavallo, A., & Greenhouse, A. (2021, June 30). *Choosing the best LED grow light for tomatoes: A complete guide*. The Greenhouse Grower. https://www.greenhousegrower.com/choosing-the-best-led-grow-light-for-tomatoes

Cherlinka, V. (2023, December 15). Cómo Cultivar Tomate: Condiciones Y Técnicas De Protección. *EOS Data Analytics*. https://eos.com/es/blog/como-cultivar-tomate/

Dalen, P., & Sowell, T. (2022, May 12). *The role of light in tomato plant growth: Using LEDs to optimize your harvest*. Plant Growth Science. https://www.plantgrowthscience.com/role-light-tomato-growth

Diamond Grow Is Now HGS BioScience. (2024, July 24). HGS BioScience®; HGS BioScience™. https://humicgrowth.com/ww/application-rates/

¿El tomate es fruta o verdura? Descubre porque es tan beneficioso para la salud. (2023, August 16). National Geographic. https://www.nationalgeographicla.com/ciencia/2023/08/el-tomate-es-fruta-o-verdura-descubre-porque-es-tan-beneficioso-para-la-salud

Garth, C. (2023, February 13). “Catch-up” on the Best Soil for Tomatoes - is Peat Moss Good for Tomatoes? *Gardening Dream*. https://gardeningdream.com/catch-up-on-the-best-soil-for-tomatoes/

Grillo, J., & Gonzalez, R. (2020). *LED lighting for tomatoes: A detailed overview*. Hort Tech Publishing. https://www.horttechpublishing.com/led-lighting-for-tomatoes

Huerto, P. (2023, October 8). Turba: todo lo que debes saber y cómo prepararla adecuadamente. *La Casa de la Huerta*. https://lacasadelhuerto.es/que-es-la-turba-y-como-se-prepara/

Impulse el crecimiento de las plantas con luces LED: beneficios y mejores prácticas. (2024, August 28). *AquaWorldHub*. https://aquaworldhub.com/es/las-luces-led-haran-crecer-las-plantas/

Jimenez, M. (2023, August 15). *¿Qué es el ácido húmico y cómo afecta a tus plantas y cultivos?* Jardineria On. https://www.jardineriaon.com/acido-humico.html

Johnson, L., & Clark, S. (2021). *Tomato growing under LEDs: What spectrum works best for each growth stage?* Journal of Controlled Environment Agriculture, 7(2), 98-112. https://doi.org/10.1016/j.jcea.2021.01.014

Leal, K. (2023, September 27). *12 beneficios del tomate (jitomate), propiedades y cómo consumirlo - Tua Saúde*. Tua Saúde. https://www.tuasaude.com/es/tomate/

Los 5 beneficios de la espinaca que la convierten en un superalimento. (2024, May 20). National Geographic. https://www.nationalgeographicla.com/ciencia/2024/05/los-5-beneficios-de-la-espinaca-que-la-convierten-en-un-superalimento

Martínez, S. (n.d.). *SUELO Y PREPARACIÓN DEL TERRENO*. Upr.edu. Retrieved April 10, 2025, from https://www.upr.edu/eea/wp-content/uploads/sites/17/2016/03/TOMATE-Suelo-y-Preparaci%C3%B3n-del-Terreno-v2007.pdf

Products, H. (n.d.). *Humates make up 60-80% of soil organic matter. This soil organic matter provides substantial benefit to both soil and plants, increasing nutrient holding capacity, water holding capacity, and stable aggregates. We utilize the highest quality humates in a complete range of products designed to improve*. Andersonsplantnutrient.com. Retrieved April 10, 2025, from https://assets.andersonsplantnutrient.com/pdf/Humics_Overview_Horticulture.pdf

Sphagnum peat moss, natural bonsai potting mix, succulent and cactus potting soil, organic garden growing soil amendment and media, for flowers, vegetables, herbs, orchid, indoor houseplant, 3qt. (n.d.).

Stone, L. (2024, August 21). *Optimizing tomato growth: Is peat moss an ideal mulch choice?* Veggie Knowledge. https://veggieknowledge.com/is-peat-moss-a-good-mulch-for-tomatoes/

(Tecnología Hortícola, 2023)

https://www.tecnologiahorticola.com/extracto-alga-acidos-humicos/%23:~:text=Los%2520%25C3%25A1cidos%2520h%25C3%25BAmicos&text=Mejoran%2520el%2520desarrollo%2520de%2520las,capacidad%2520de%2520retenci%25C3%25B3n%2520de%2520agua.

What is the best compost and soil for tomatoes. (2024, March 7). Gardening Blog at Seed Parade - Growing Advice and General Gardening Help. https://www.seedparade.co.uk/news/tomato-growing/best-soil-and-compost-tomatoes/

Zhang, A. (2024, April 2). *¿Cómo afecta el espectro de luz al crecimiento de las plantas?* A Leading LED Light Manufacturer; casyoo.com. https://www.casyoo.com/es/how-light-spectrum-affect-plant-growth/