

**The Effects of the Wavelength of Light on the Growth of Lettuce (*Lactuca sativa*)
Cultivated in Martian Regolith**

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Introduction

To understand the potential of life beyond Earth, there is a strong call for continued space exploration. According to the National Aeronautics and Space Administration (NASA), they are returning to the moon for scientific discovery, economic benefits, and inspiration for a new generation of explorers: the Artemis Generation (NASA, 2024). The scientific discoveries from the moon can then be used to gather more information about Mars and the solar system. Mars, however, is the ultimate goal for human exploration because it is one of the only other places known where life may have existed in the solar system (NASA, 2023).

NASA will be exploring Mars and more of the solar system; however, those expeditions can be very long and challenging. This means that there will be a need for methods that will allow explorers to grow sustainable crops while they complete their mission. According to the Plant the Moon Challenge (2024), individuals from various education levels are coming together and developing experiments that modify lunar or Martian regolith to grow the best nutrient rich crops (2024). The goal of these experiments is to maximize the crop yield while limiting the amount of mass that is needed from Earth. According to Shaw and Soma (2022), space missions are becoming longer so the quality and nutrition of food need to be improved, as the astronauts' health and wellbeing (both physical and mental) are highly dependent on diet (Shaw and Soma, 2022). It is incredibly important that the astronauts remain healthy so that they can continue their mission providing information that advances scientific discoveries.

The goal of this project is to investigate how different wavelengths of light impact the growth of Butterhead lettuce (*Lactuca sativa*) in Martian regolith. The hypothesis is that the growth and physiological development of Butterhead lettuce grown in Martian regolith will vary depending on the wavelength of light provided, with plants exposed to combined red and blue wavelengths producing greater biomass and chlorophyll content than those grown under red, blue, or full-spectrum light alone.

Key terms: *Lactuca sativa*, Martian regolith simulant, wavelength of light, biomass, chlorophyll content

Theory

Martian regolith has been studied for years, and most researchers agree that it does not act like Earth soil. Martian regolith is composed of basaltic sand, dust, and crushed volcanic rock with almost no organic matter (Let's Talk Science, 2025). Because it has no microorganisms or decomposed plant material, it cannot cycle nutrients the way Earth soil does. This also means the regolith has a naturally alkaline pH, usually between 8.5 and 9.5, which is far outside the preferred range for crops like lettuce. The alkalinity of Martian regolith interferes with the availability of phosphorus, iron, and zinc thus preventing plants from absorbing the nutrients they need to survive (Temming, 2020).

A second major limitation is the presence of perchlorates which are toxic chlorine-based salts found across the Martian surface. Perchlorates not only harm plant growth but also makes it unsafe for humans if they accumulate in edible leaves (Temming, 2020). Water behavior in Martian regolith is also a major challenge. Cartier (2023) reports that regolith simulants dry out rapidly and compact into dense layers that restrict root penetration. The soil particles are so fine that they either drain water too quickly or trap it in pockets without proper aeration. Mathewson (2016) found that lettuce grown in simulants required small, frequent waterings to prevent soil hardening and moisture stress. This matches patterns seen across multiple Mars-growing studies, which show that soil moisture must be controlled carefully to avoid both drought and oversaturation.

Nutrient deficiencies add another layer of difficulty. Although regolith contains minerals such as iron, magnesium, and calcium, it lacks essential macronutrients like nitrogen and phosphorus. Because of this, many Earth-based experiments combine Martian simulants with soil amendments. Duri et al. (2022) found that mixtures of simulants and organic material significantly improved water retention, chlorophyll levels, and overall biomass in lettuce. Amendments such as worm castings, compost, manure, and perlite help improve soil structure and nutrient availability.

Since researchers do not have access to Martian soil, they rely on regolith simulants like MMS-1 which reproduces the chemical and physical properties of Martian basalt, allowing controlled experiments on crop growth under Mars like conditions (Kasiviswanathan et al., 2025). Studies using MMS-1 consistently show that lettuce can grow, but only when the

regolith is amended, watered properly, and adjusted chemically to reduce alkalinity. Understanding these limitations is important for this project because it explains why the regolith must be modified before testing how different wavelengths of light influence lettuce growth.

Scientists and astronauts recognize the constant need for food and nutrition, particularly from a sustainable and efficient source. Through trial and error, lettuce (*Lactuca sativa*) is one of the best crop options for many reasons, such as short growth cycle, nutritional value, and performance in controlled environments. In a 2019 study by El-Nakhel et al., where two varieties of lettuce were compared in terms of performance, both grew quickly, where one even managed to outgrow the other, implying a shorter harvest schedule to attain the target weight and maturity stage requirement. This fast growth emphasized the efficient harvest that can come from lettuce, and even leading to less consumption of water and minerals for reaching target produce (El-Nakhel et al., 2019).

Lettuce's ability to grow quickly hits one of the goals of an exceptional crop model because astronauts' access to food is always limited. In a 2020 article by Burgess et al., researchers presented a theoretical plan to biofortify lettuce crops to increase nutrients that are already found in them. In the article, they concluded that lettuce "presents a model starting point for the generation of new space farming systems and biofortified crops to meet human nutritional requirements" (Burgess et al., 2020). This further strengthens the fact that lettuce is a model crop because it offers a meaningful foundation of vitamins, antioxidants, and minerals important to an astronaut's diet.

Combined with all lettuce's efficiency, it was also found to be a resilient crop in harsh environments. In a 2011 study by Wheeler et al., where many crops were grown in controlled environments, the scientists found that lettuce could withstand decompression down to ~1.5-2.0 kPa for up to 30 min with no apparent damage. This resilience is also clear when it comes to different wavelengths of light. In a 2010 study by Hogewoning et al., different wavelengths of light were tested, such as white light, blue light, and red light. From this study, it was found that the total biomass under only the red-light spectrums was greatly reduced, and that growth and development had been inhibited, which leads to decreased chlorophyll content. In the same study, when both red and blue were combined,

the physiological disorders associated with leaf development under red light alone were eliminated by adding only a small amount of blue light, further supporting the fact that red and blue light are needed to promote growth and development of lettuce crops (Hogewoning et al., 2010). Different wavelengths of light affect plant growth because plants absorb certain parts of the spectrum better than others; photosynthetic pigments exhibit maximal absorption in the red and blue regions of the spectrum (Hogewoning et al. 2010, p. 111). This is why most research focuses on red and blue light emission diodes (LEDs) when studying how plants develop in controlled environments.

Red light, which is usually around 660 nanometers, strongly supports photosynthesis and increases plant growth. Hernández and Kubota (2016) found that red wavelengths near 660 nm significantly enhance biomass accumulation and leaf expansion in leafy vegetables (p. 45). This wavelength encourages bigger leaves, faster growth, and more total biomass. At the same time, too much red light in small or enclosed spaces can create stress. Johkan et al. (2012) reported that overexposure to red LEDs increased leaf temperature and caused tip burn under enclosed conditions (p. 7), showing that red light must be used with control and proper distance. On the other hand, blue light, usually around 450 nanometers, plays a different role. It influences chlorophyll formation, the strength of the leaf, and the shape of the plant. Stutte (2009) noted that blue light is essential for normal photomorphogenesis and chlorophyll development (p. 115). Blue wavelengths increase pigment levels, create thicker and darker leaves, and keep plants compact. Pennisi et al. (2019) showed that higher amounts of blue light can increase pigments but reduce fresh weight, which confirms that red and blue need to be balanced for healthy growth. Full-spectrum light on the other hand, provides a wide range of wavelengths similar to natural sunlight. Snowden et al. (2016) says that broad-spectrum white LEDs produce morphology similar to sunlight-grown plants and serve as an effective control condition in controlled-environment studies (p. 66). Full-spectrum lighting creates a natural baseline that helps compare how plants react when only red or blue wavelengths are used.

Research on lettuce and other leafy greens shows the same pattern across different studies. A mix of red and blue light produces the strongest and healthiest growth, proving to be the best option. Red-dominant conditions increase leaf size, while blue-dominant conditions

build stronger leaves with deeper color. Full-spectrum light creates natural-looking plants but is less efficient because plants do not use all wavelengths equally as supported by NASA’s findings. Hummerick et al. (2020) reported that lettuce grown under red and blue LEDs showed robust growth and acceptable morphology for spaceflight crop production (p. 4), which matches the results seen in other controlled-environment research. Red light increases photosynthesis and leaf expansion, blue light strengthens chlorophyll and structure, and full-spectrum light provides a natural point of comparison. These studies support the idea that the best approach is a combination of full-spectrum lighting and targeted red and blue wavelengths when studying how plants grow in controlled environments.

Overall, lettuce is one of the best crops to cultivate in harsh and nutrient deficient conditions, as it can withstand them to a certain extent. In addition, it is full of nutrients and is an efficient grower because its rapid growth limits water consumption and the wait from seed to harvest. Lettuce has been found to grow best in the combination of blue and red light as opposed to being used separately, which supports the project’s hypothesis.

Measurement Methods

Table 1: Materials and Descriptions

Category	Description
Crop	Butterhead lettuce (<i>Lactuca sativa</i> var. capitata)
Soil Composition	50% Martian regolith simulant, 40% topsoil, 10% perlite
Fertilizer/Amendment	Worm castings
Light Sources	1. Full-spectrum LED 2. Red LED (~660 nm) 3. Blue LED (~450 nm) 4. Combined red/blue LED
Water Source	Distilled water
Containers	3-inch pots

Instruments	pH meter, Electrical Conductivity (EC) meter, chlorophyll meter (SPAD), ruler, analytical balance, drying oven, thermometer, hygrometer
Growth Environment	Indoor chemistry lab with controlled humidity and temperature

Table 2: Experimental Design

Variable Type	Description
Independent Variable	Wavelength of light source
Dependent Variables	Plant height, chlorophyll content, fresh and dry biomass, soil pH, soil EC
Controlled Variables	Soil mix, pot size, water volume, light exposure time (12-hour light / 12-hour dark), plant type (butterhead lettuce), distance from light (20–25 cm), temperature and humidity

Table 3: Experimental Setup

Light Sources	Full Spectrum/Red light/Blue light/Red & Blue Light					
Sample ID	1A	1B	2A	2B	3A	3B
Soil Composition	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite
Volume of regolith (mL)	100	100	0	0	50	50
Volume of Topsoil (mL)	0	0	100	100	40	40
Volume of Perlite (mL)	0	0	0	0	10	10
Amendment (fertilizer)	None	None	None	None	1 TBSP Worm Castings (~7.5g)	1 TBSP Worm Castings (~7.5g)

Procedure

1. **Soil Preparation:** Each pot was filled with ~100 ml of the soil mixture (50% regolith, 40% topsoil, 10% perlite and 7.5 grams of worm castings). This will be referred to as soil mixture throughout the article. Soil pH and EC were measured on the day of planting.
2. **Growth Conditions:** Plants were grown indoors under controlled temperature and humidity. Light sources were positioned 20–25 cm above the lettuce plants. Plants were grown in 3-gallon aquariums that were covered with aluminum foil ensuring that plants were only exposed to the appropriate light sources and wavelengths.
3. **Watering Schedule:** Each pot received 10 - 15 mL of distilled water depending on the moisture level of the plants. Plants were initially watered twice per week, but the schedule was modified to once per over the growth period to prevent overwatering of the plants. Watering volume and frequency was consistent for all samples.
4. **Monitoring and Measurements:** Weekly measurements included plant height, number of leaves, number of plants, and chlorophyll content (SPAD – soil and plant analysis development). Harvest measurements included fresh and dry weight (after drying at 60 °C for 48 h), and final soil pH. Room conditions were recorded weekly.
5. **Data Analysis:** Data was recorded in an excel spreadsheet and shared using the college's one drive system (Microsoft). Collected data was compared across treatments to determine the effect of light wavelength on lettuce growth. Statistical analyses such as mean values and standard deviations were calculated to test significance.

Analysis & Results

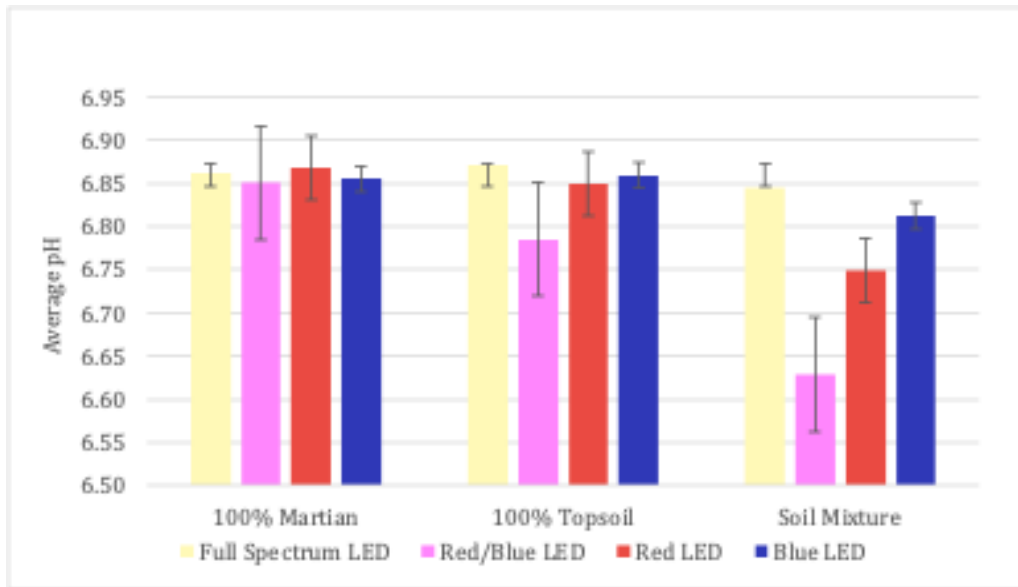


Figure 1: Average pH of Soil Samples

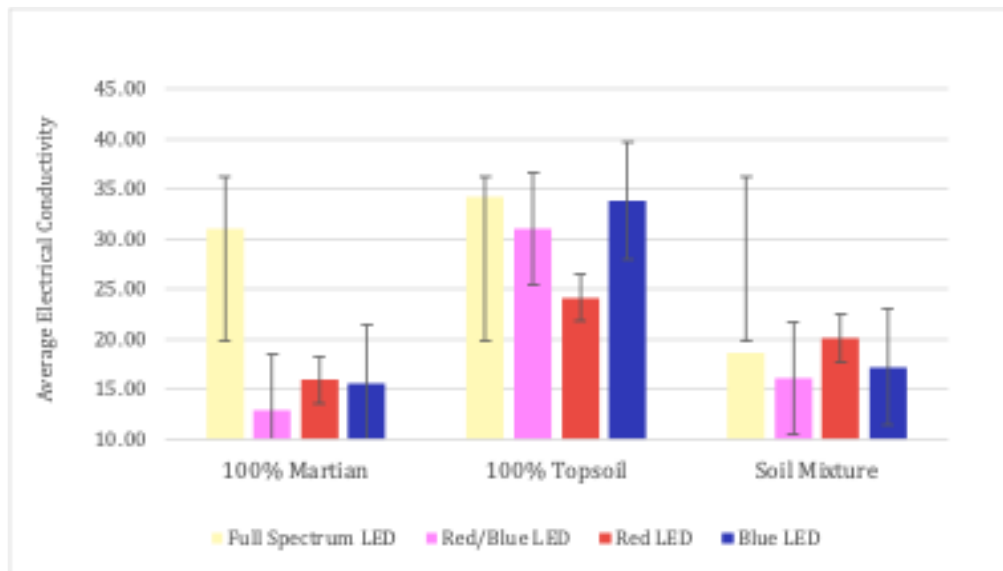


Figure 2: Average Electrical Conductivity of Soil Samples

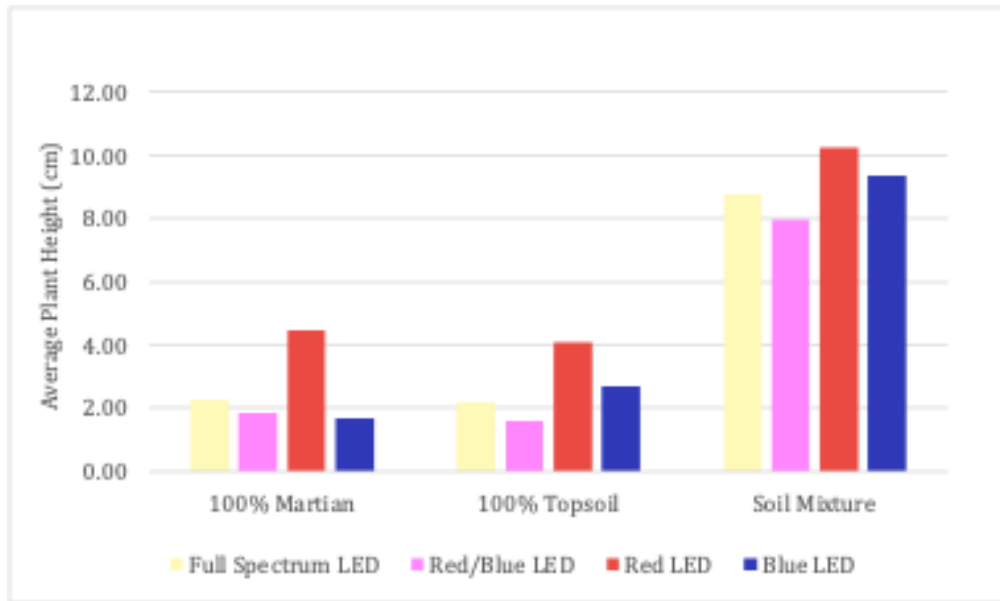


Figure 3: Average Plant Height for Plants under all the Light Conditions

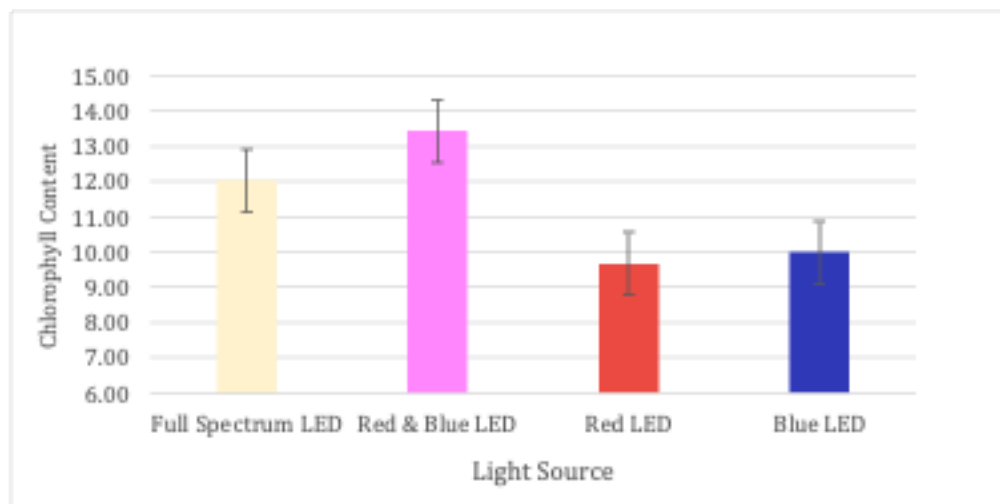


Figure 4: Average Chlorophyll content of the Soil Mixture Plants

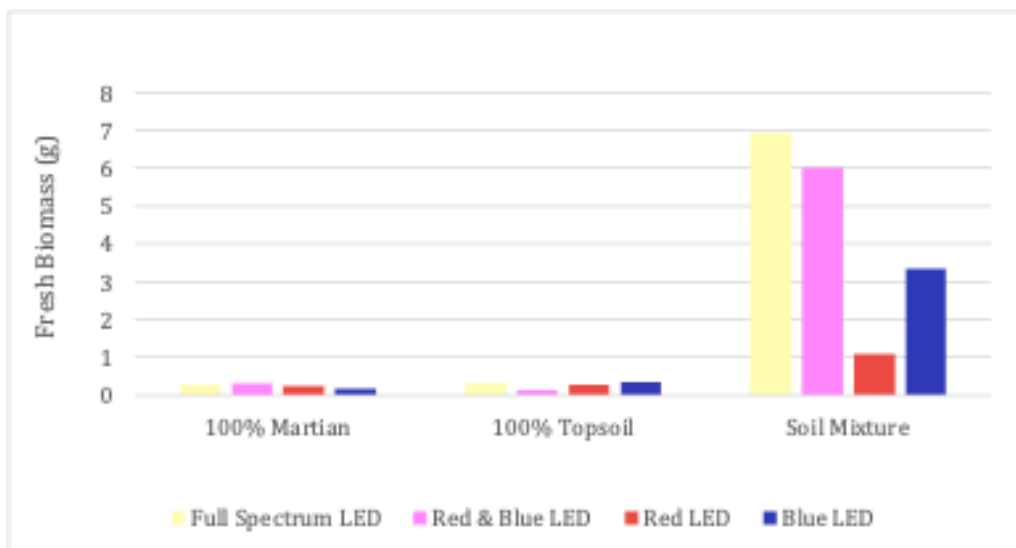


Figure 5: Week 7 Fresh Biomass for all Plants under all Light Conditions

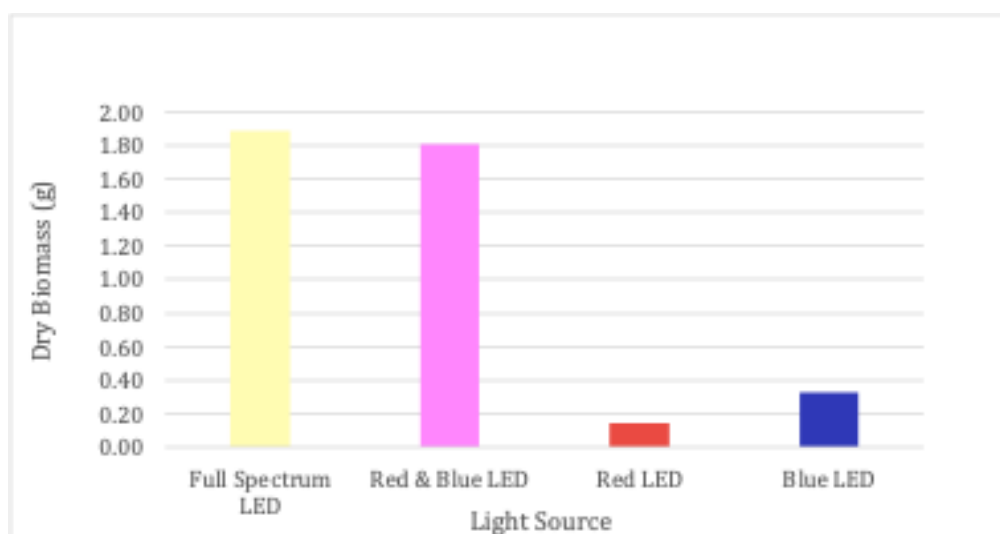


Figure 6: Week 7 Dry Biomass for Soil Mixture Plants under all Light Conditions

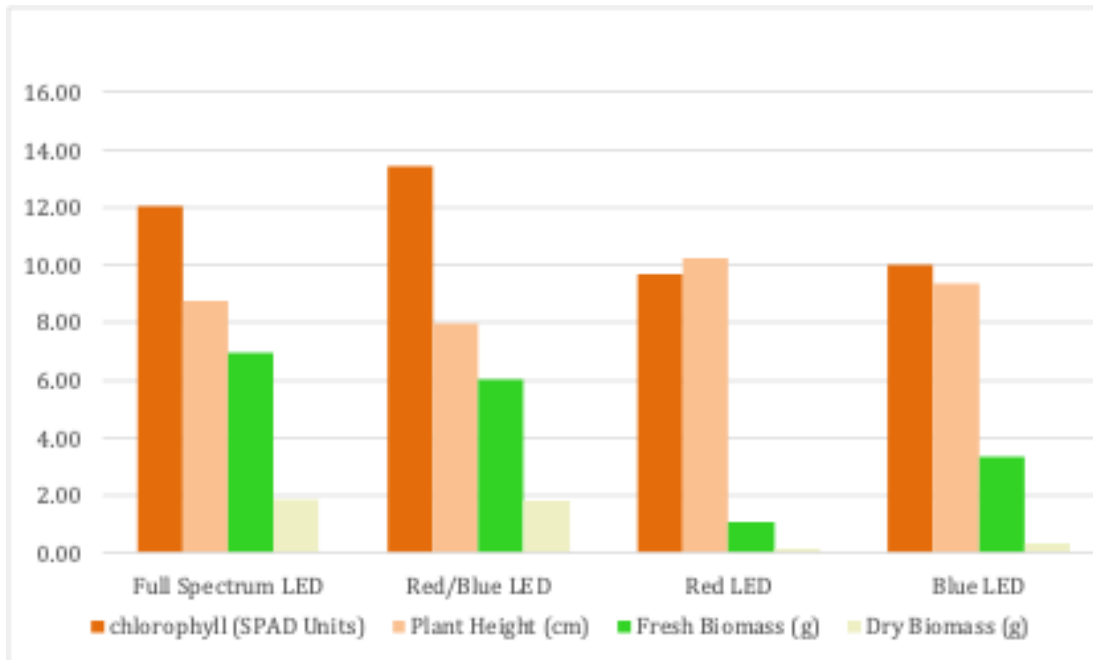


Figure 7: Comparison between Measured Values under all the Light Conditions

Discussion & Conclusions

The growth period spanned seven weeks, as the eighth week coincided with the college's spring break. Throughout this time, plant growth was observed in all soil samples, including the 100% Martian regolith, the 100% topsoil, and the soil mixture composed of 50% Martian regolith, 40% topsoil, 10% perlite, and worm castings as fertilizer. Each soil type displayed distinct physical characteristics. The Martian regolith was highly granular, allowing water to pass through quickly, while the topsoil was less absorbent, causing water to pool on the surface before gradually being absorbed. In contrast, the soil mixture showed a balanced combination of drainage and absorption, allowing it to retain moisture more effectively. These differences in soil texture presented challenges in maintaining a consistent watering schedule, as each sample required varying amounts of water (10 – 15 mL). As a result, both the watering schedule and volume had to be adjusted throughout the growth period.

An additional observation was the presence of condensation within the aquariums exposed to the red/blue light combination and the full-spectrum light source, suggesting differences in moisture retention under these lighting setups. The average temperature and humidity inside the lab were 72 °F and 70%, respectively. However, the temperature and humidity within the aquariums varied slightly depending on the light source used. The average temperatures in the aquariums exposed to individual red and blue light sources were 76 °F and 75 °F, respectively. In comparison, the aquariums with full-spectrum lighting and the red/blue light combination had average temperatures of 77 °F and 82 °F, respectively. Although the average temperature in the full-spectrum setup appeared similar to that of the individual light treatments, the daytime temperatures in this aquarium reached as high as 80 °F. These elevated temperatures may have contributed to the condensation observed in these aquariums; however, this effect was not reflected in the recorded humidity values. A likely explanation is that the humidity measurements were taken after harvesting, when the plants were no longer present to contribute to moisture levels, potentially resulting in less accurate humidity readings.

Weekly analysis of soil pH and electrical conductivity indicated that the soil composition, rather than the light source, was the primary factor influencing these properties (Figures 1 and 2). The pH of all soil samples was slightly acidic, ranging from 6.6 to 6.8, which falls within the optimal range for most plant growth. Electrical conductivity measurements were highest in the 100% topsoil samples, indicating a greater ion concentration compared to the 100% Martian regolith and the soil mixture samples. The lettuce seeds successfully germinated in all soil types, with visible sprouting occurring within five days of planting. However, the growth rates varied across the samples; plants grown in the soil mixture exhibited the greatest increase in height, outperforming those grown in both 100% Martian regolith and 100% topsoil. These findings suggest that the soil mixture composed of Martian regolith, topsoil, perlite, and worm castings provides a more favorable environment for plant growth, lessening some of the limitations associated with growth in 100% Martian regolith.

The superior growth observed in the soil mixture was consistent across all light treatments (Figure 3). Within this soil condition, plants grown under red light achieved the greatest height, with an average of 10.24 cm over the growth period and a relative growth rate of 0.28 cm/week. These findings align with previous research indicating that red light can enhance plant growth. However, despite their greater height, plants grown under red light appeared thin and less robust compared to those grown under the full-spectrum and combined red/blue light sources. The plants exposed to full-spectrum and red/blue lighting exhibited fuller, healthier morphology, suggesting that while red light promotes elongation, a broader light spectrum supports a more balanced plant development.

Chlorophyll content was measured beginning in week four of the growth period, when the leaves had reached sufficient size for accurate measurements using a chlorophyll meter. Measurements were conducted only on the lettuce plants grown in the soil mixture, as leaves from the other soil conditions were too small for reliable measurements. Plants grown under the red/blue light combination possessed the highest chlorophyll content, followed by those grown under the full-spectrum light source. The average chlorophyll content for plants under the red/blue light was 13.44

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(SPAD) units, compared to 9.66 SPAD units for plants grown under red light alone (Figure 4). These results suggest that the combined red/blue light treatment is more effective in promoting chlorophyll accumulation than red light alone.

While chlorophyll content is a useful indicator of plant health, biomass provides a more direct measure of the effectiveness of the photosynthesis process and therefore the overall plant productivity so both fresh and dry biomass were measured at the end of the growth period. Fresh biomass was recorded for all plant samples, and the results showed that plants grown in the soil mixture produced the highest fresh biomass compared to those grown in 100% Martian regolith and 100% topsoil (Figure 5). Among the light treatments, plants grown under full-spectrum lighting exhibited slightly higher fresh biomass than those grown under the red/blue light combination, with average values of 6.94 grams and 6.02 grams, respectively.

Because fresh biomass includes retained water, dry biomass was also measured to provide a more accurate assessment of plant growth. Dry biomass measurements were conducted only on the soil mixture samples, as these exhibited the most robust and healthy growth. The samples were dried overnight in an oven set to 60 °C prior to measurement. Results indicated that plants grown under full-spectrum and combined red/blue light produced greater dry biomass than those grown under individual red or blue light treatments. Among these, the full-spectrum condition yielded slightly higher dry biomass than the red/blue combination, with a minimal difference of 0.08 grams units between the two (Figure 6).

The results obtained are consistent with previous research indicating that while individual red and blue light sources can support plant growth, a combination of both is necessary to promote strong, healthy development (Figure 7). Although plants grown under single-wavelength light sources exhibited greater height, those exposed to combined red/blue and full-spectrum lighting demonstrated superior overall health. This was shown by higher chlorophyll content and greater biomass, supporting the hypothesis that plants exposed to combined red and blue wavelengths produce greater biomass and chlorophyll levels than those grown under red or blue light alone.

These results indicate that the soil mixture, when combined with either red/blue or full-spectrum lighting, supports the growth of robust and healthy plants. Future research could focus on evaluating the nutritional viability and overall quality of these plants. Measurements such as photosynthesis efficiency and nutritional composition would provide deeper insight into not just plant growth but also their suitability as a nutritious food source.

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Appendices: Raw Data

Table 1: Week 1 Data

Light Source	Full Spectrum						Red LED						Blue LED						Red/Blue LED					
Sample ID	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B
Soil Composition	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite
Number of plants																								
Number of leaves																								
pH	6.78	6.85	6.71	6.68	6.64	6.55	6.95	7.37	6.57	6.63	6.13	6.2	6.68	6.74	6.79	6.57	6.28	6.43	6.5	6.75	6.84	6.61	6.43	6.36
EC (micro Siemens)	36	28	79	90	36	31	22	25	249	245	49	49	20	19	78	66	51	24	14	12	68	77	32	31
Volume of Water added (mL)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Chlorophyll Level																								

Table 2: Week 2 Data

Light Source	Full Spectrum						Red LED						Blue LED						Red/Blue LED					
Sample ID	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B
Soil Composition	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite
Number of plants	3	2	3	1	4	3	4	2	2	3	2	3	0	4	3	2	3	4	4	3	0	1	2	3
Number of leaves	8	4	8	2	8	8	4	2	4	6	4	6	0	8	6	4	8	6	7	6	0	2	4	6
Plant Height (cm)	1.50	1.40	1.60	2.80	1.40	1.50	2.40	3.00	1.80	0.90	3.20	3.50	0.80	0.80	0.40	0.90	0.50	1.50	1.80	1.00	0.00	0.30	0.80	0.50
pH	7.09	7.17	6.84	6.88	7.37	7	7.14	7.03	6.85	6.88	6.75	6.96	6.94	6.84	7.02	6.88	6.9	6.68	6.84	6.82	6.75	6.78	6.78	7
EC (micro Siemens)	41.1	44.8	22.2	33.3	11.2	12.9	12.3	10.7	11.9	12.3	10.4	10.7	11.2	11.6	19	13.7	13.1	12	10.4	8.3	16.6	9.6	8.9	9.2
Volume of Water added (mL)																								
Chlorophyll Level																								

Table 3: Week 3 Data

Light Source	Full Spectrum						Red LED						Blue LED						Red/Blue LED					
Sample ID	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B
Soil Composition	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite
Number of plants	3	2	3	2	3	2	3	2	3	3	2	3	0	4	3	2	3	4	4	3	1	1	2	3
Number of leaves	13	8	9	6	16	13	8	6	10	10	8	11	0	12	9	6	10	12	14	11	2	5	11	13
Plant Height (cm)	3	2.2	2	2	5.1	5.5	5	7	4.9	5	8	9.2	0	3	3.3	3.5	5	5.2	2	1.6	0.6	2	4	4.1
pH	6.59	6.82	6.59	6.91	6.48	6.67	6.61	6.56	6.57	6.52	6.52	6.51	6.84	6.63	6.5	6.63	6.64	6.61	6.62	6.8	6.47	6.52	6.53	6.05
EC (micro Siemens)	28.2	16.6	19.7	18.6	17.9	13.6	15.4	13	17.1	14.7	14.2	14	11.5	10.1	10.6	18.1	11.3	11.4	9.6	9.4	13.9	19.7	9.9	9.6
Volume of Water added (mL)																								
Chlorophyll Level																								

Table 4: Week 4 Data

Light Source	Full Spectrum						Red LED						Blue LED						Red/Blue LED					
Sample ID	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B
Soil Composition	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite
Number of plants	4	3	4	2	4	4	4	2	2	3	3	4	0	4	3	2	3	4	4	3	1	2	2	
Number of leaves	16	10	15	8	29	20	15	9	9	11	9	13	0	16	12	8	13	20	15	12	3	6	19	
Plant Height (cm)	3	2.5	2.5	2	16	14.5	5	7	6.9	4.8	14	9.5	0	3	3.3	3	7	9.5	2.2	1.6	0.7	2	13	13.5
pH	6.68	6.69	6.73	6.63	6.78	6.59	6.62	6.13	6.6	6.55	6.69	6.68	6.57	6.75	6.63	6.78	6.89	6.6	6.61	6.72	6.55	6.74	6.57	6.71
EC (micro Siemens)	44.8	24.5	28	30.3	21.6	21.9	21.7	16.2	27	28	20	15	14.9	15.4	32.3	28.8	14.4	16.6	12	14	29.1	19.3	13.7	14.9
Volume of Water added (mL)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Chlorophyll Level					6.5	3.3					1.9	2.9						2	2.9				5.7	5.3

Table 5: Week 5 Data

Light Source	Full Spectrum						Red LED						Blue LED						Red/Blue LED					
Sample ID	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B
Soil Composition	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite
Number of plants	3	3	4	2	4	3	3	2	2	3	3	3	2	3	3	2	3	4	4	3	1	2	3	3
Number of leaves	15	14	16	8	23	21	16	9	10	13	15	13	4	14	13	10	15	17	19	11	3	6	22	22
Plant Height (cm)	3	2.6	2.9	2.2	11	10	5	7.5	5.5	3.2	17	14	1	2.5	2.3	3	13	14	1	1.5	0.5	1.1	9	8.5
pH	6.87	7.02	7.3	7.1	7.2	7.4	7.3	7.2	7.24	7.21	7.42	7.36	7.26	7.39	7.13	7.14	7.33	7.32	7.24	7.38	7.16	7.12	7	7.16
EC (micro Siemens)	32.8	26.8	17	31.4	16.4	14.8	12.3	12.2	30.9	29.1	13.7	14.1	11.3	14.8	10.7	21.5	11.2	13.2	12.7	13.7	18.4	37.7	15	14.5
Volume of Water added (mL)																								
Chlorophyll Level					1.8	2.2					0.1	0.1					0.7	0.7					1.5	1.3

Table 6: Week 6 Data

Light Source	Full Spectrum						Red LED						Blue LED						Red/Blue LED					
Sample ID	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B
Soil Composition	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite
Number of plants	3	3	3	2	4	4	4	2	1	2	3	3	1	3	3	2	3	3	3	2	2	3	3	2
Number of leaves	18	14	18	9	25	21	17	13	4	8	19	19	6	19	14	10	18	20	16	10	11	13	11	15
Plant Height (cm)	2	2	2.5	2	10	9.2	1	1.5	0.7	1.6	8	8.5	1.2	3.5	3	4	14	14	2	6.5	5.5	4	13	12
pH	6.75	6.86	6.96	6.97	6.98	6.91	7.04	7.08	7.08	7.04	7.01	6.56	6.88	6.84	6.93	7.08	7.1	6.99	7.01	6.95	6.78	6.85	6.95	6.83
EC (micro Siemens)	49.1	20.7	27	28.4	15.6	15.5	12.5	11.4	28.5	28.1	15.7	18.6	14.5	39	16.8	37.9	17.3	15.4	13.2	24.2	13.7	24.3	14.1	15.2
Volume of Water added (mL)																								
Chlorophyll Level					22.7	20.9					24	17.7					19.7	20.7					24	17.6

Table 7: Week 7 Data (last week of data collection because of spring break)

Light Source	Full Spectrum						Red LED						Blue LED						Red/Blue LED						
Sample ID	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	1A	1B	2A	2B	3A	3B	
Soil Composition	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	100% Martian Simulant	100% Martian Simulant	100% Top Soil	100% Top Soil	50% Martian Simulant, 40% Top Soil, 10% Perlite	50% Martian Simulant, 40% Top Soil, 10% Perlite	
Number of plants	3	3	3	3	2	3	3	3	2	2	3	2	2	2	4	3	2	3	3	3	3	1	1	3	3
Number of leaves	19	12	21	11	25	19	17	9	10	17	8	12	6	17	14	12	16	18	20	13	5	7	20	18	
Plant Height (cm)	1.9	2	2.3	1.8	1.1	10	4	5.3	7.5	7	16	12	2	3	2.8	2.6	14.5	14	1	1	1	1.3	9	8	
pH	6.9	7	6.95	6.94	6.67	6.59	6.74	6.39	7	7.1	6.6	7.1	6.62	7.09	7.1	6.85	6.82	6.8	6.98	6.89	6.88	7.1	6.84	6.88	
EC (micro Siemens)	31	15.6	23.4	30.7	15.5	17.8	18.9	19.5	39.4	32.7	17.2	19.8	14.2	10.8	22.7	47.7	15.2	14.7	151.9	14.7	64	23.8	16.8	13.5	
Volume of Water added (mL)																									
Chlorophyll Level					18.2	20.6					14.1	16.5					18.2	15						27	25.9
Fresh Biomass (g)	0.234	0.27	0.439	0.202	7.034	6.844	0.292	0.178	0.253	0.325	1.097	1.09	0.06	0.315	0.379	0.292	3.135	3.552	0.335	0.253	0.082	0.156	5.287	6.736	
Dry Biomass (g)					1.759	2.016					0.172	0.116					0.284	0.374					1.454	2.312	

Photos



Figure 1: Pots being prepped for planting

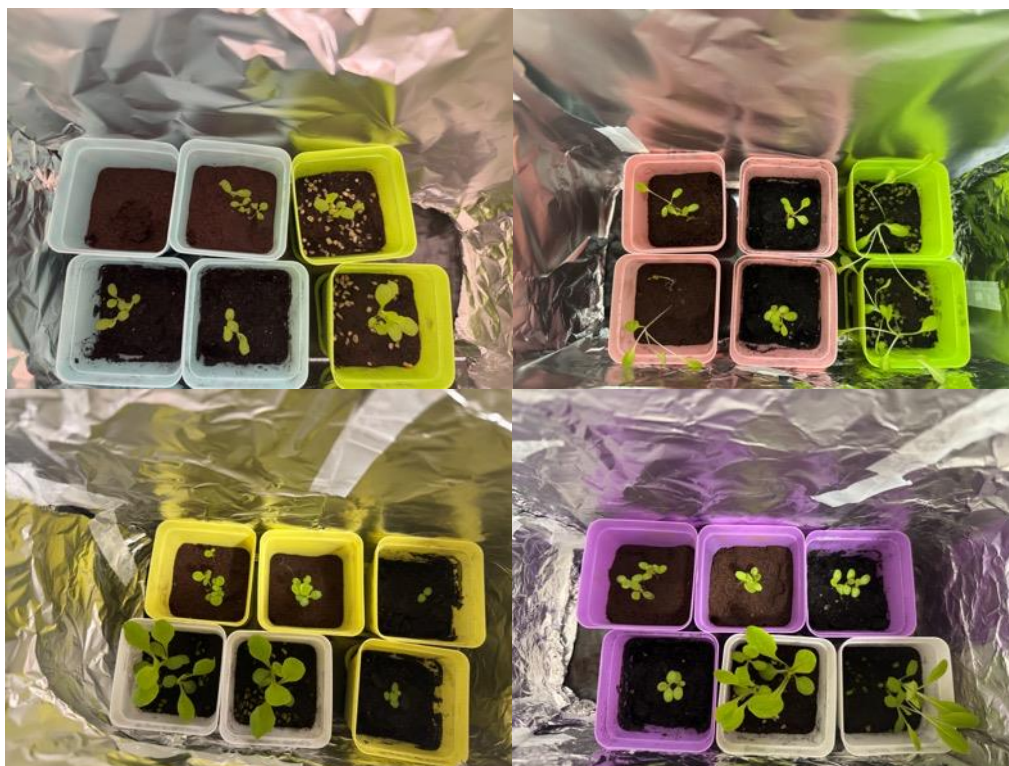


Figure 2: Week 3 (L-R: Blue, Red, Red/Blue and Full Spectrum)

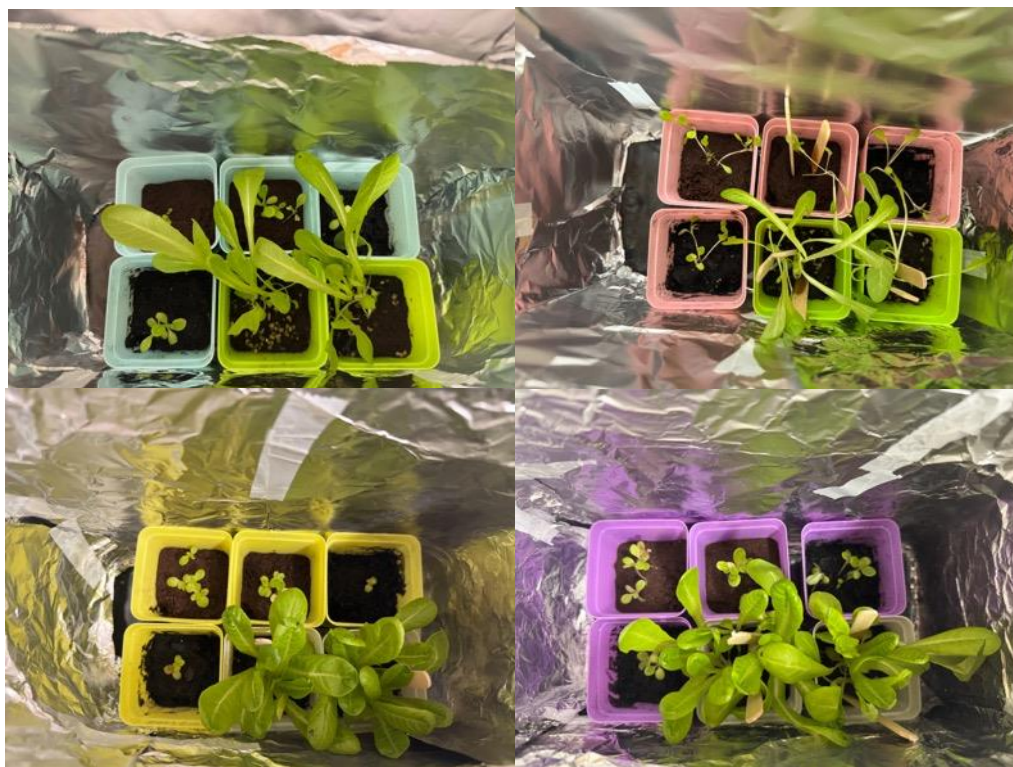


Figure 3: Week 5 (L-R: Blue, Red, Red/Blue and Full Spectrum)



Figure 4: Week 7 (L-R: Blue, Red, Red/Blue and Full Spectrum)