Hydroponics vs. Soil Planting

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Abstract

The purpose of this experiment was to investigate the effectiveness of different agricultural practices. Plants are a necessity. They provide food, oxygen to breathe, medicine, materials, and much more. The main method for growing plants is soil. Soil is unreliable because it is affected by weather changes, seasonal transitions, and its composition could be harmful, potentially containing pests, insects, or other organisms that would detriment plant growth. An alternative method is hydroponics, the cultivation of plants without soil. The goal of this experiment was to support an efficient solution for plant growth that would be the most optimal under an indoor setting of two groups: soil and hydroponics. This experiment hypothesized that if plants are grown with hydroponics, then they will grow more efficiently than soil-planting because of the usage of nutrient-based water. The procedures were setting up the experiment. Two 27-gallon bins had been for the regular hydroponics and hydroponics 1.5% levels each with 5 trials, and the control (soil) had 5 trials that received 100mL of water every day. A circulation system was used for the hydroponics since water needed to be recycled, including the nutrient solution. Throughout the 30 days, the plants were measured utilizing a 300mm ruler daily. After conducting two t-tests, the results were significant when comparing the mean height. The control grew the most compared to the other levels. Although the data was significant, the hypothesis was not supported, thus supporting soil-based planting as the most efficient method rather than hydroponics.

Introduction

Plants have an essential role in daily life on Earth, providing food for humans, oxygen to breathe, ingredients for medicine, materials (wood, fibers, rubber), and much more. Plants can do this by growing and developing as they go through many stages. They start from just seeds that germinate leaves, expanding onto vegetative states, then budding, flowering, and ripening, the last stage of maturity. (*Learn The Six Plant Growth Stages*, n.d.) Plants need various resources, such as light, water, and different nutrients, chemicals, or substances that have their function in helping the plant through these stages. Knowing how to use and control these resources is optimal for plant growth. In addition, finding a reliable method for applying the resources to improve the efficiency of plant yields is vital.

The most common and well-known method for plant cultivation is through the use of soil-based plants. It is a simple concept; having an area for soil and placing seeds within the soil to grow, with light, water, nutrients, and more. Soil planting is reliable to a certain extent as it is easily accessible; it provides an environment where plants can grow and access everything they need. While soil planting has its benefits, the problem is that soil has many adverse effects. In society nowadays, amidst the significance of plants, there are better methods in growth efficiency to supplement the world's needs. These issues pertain to unreliable factors that accompany soil usage, including the constant weather changes and seasonal transitions, potential insects, pests, or other organisms that could detriment plant growth.

Moreover, within the range of human adaptations, harmful chemicals from the store or brand-bought soils often contain a numerous mixture of elements to which their effects remain unknown and uncontrollable to the regular customer. "A research project led by horticulture specialist Dennis Pittenger investigated the effects of 15 available potting mixes from retail outlets and their abilities to support seedling growth. Of the 15 products evaluated, only three met the accepted standards for pH, salinity, and aeration after irrigation. Pittenger concluded that the overall suitability of potting soil could not be determined using just the list of ingredients on the product label.” (Vincent Lazaneo, 2015) This study elaborates that the ingredients to which potting soil is made up are not statistically proven to help plants grow, showing another uncertainty of the soil-based planting method and its effectiveness. The finding above further solidifies the need for finding a more efficient and applicable method.

An alternative method would be hydroponics, the cultivation of plants without the use of soil. Hydroponics incorporates water control, with sufficient levels for the plants to grow, and that water is recycled for a certain period. Nutrients are mixed into the water. Then, the plants will grow in that environment, absorbing those nutrients and all that is needed. Compared to the soil-based planting method, the hydroponics system allows the planter to conservatively reuse less water and grow more than with soil due to a few components required for the system to work. Meanwhile, when working with hydroponics, knowledge of growth factors (nutrients and water) are manageable, unlike the soil method, where multiple outside conditions such as the moisture and state of the soil are more challenging to determine. Hydroponics allow easier adjustments to be made to fit the planter’s preferences and are suitable for home-grown plants. (*Hydroponics vs Soil: Which Is Better?*, 2020)

The purpose of this experiment is to answer the following research question: Which method of planting is more efficient in terms of plant growth: Hydroponics or Soil-based Planting? This experiment is necessary because it can be completed relatively within a human-controlled environment unaffected by changing weather conditions. In addition, this experiment examines a newer or less used method (hydroponics) compared to a commonly known way (soil), which will ultimately help support the effectiveness of different agricultural practices. The testing factors include the plants grown in hydroponics and soil. The measurements will be height after 30 days of experimentation.

This experiment hypothesizes that if plants are grown with hydroponics, they will grow more efficiently than soil-planting because of the usage of nutrient-based water. The independent variables are the nutrient and water input, with the tested groups of hydroponic plants. The dependent variable is the growth or height of the plants. The control group will be the soil-based plants. The constants are environment/location (basement of a residential area), light source (white LED lights), and time frame for experimentation (30 days). Documentation of data will be collected daily. A research finding by the Department of Engineering in King Abdulaziz University (Saudi Arabia) outlined and conducted an experiment that analyzed the growth (through height) of cucumbers in both hydroponics and soil. (Gashgari et al., 2018) The procedures supplied insight into the structure of the hydroponics system, the way water was transferred, and other components. This research project could help determine the management or setup of this experiment. In conclusion, this experiment will compare the growth of plants in hydroponics versus plants in a soil-based system, differing from the previous research as the measurements for this experiment include more than just recording height, a contrasting data source.

Methodology

The focus of this project was to determine the efficiency of hydroponics compared to soil-based planting. The independent variable level groups consist of low, middle, and high nutrient mixed solutions within the hydroponics system. The control group is plants grown using soil, also known as the traditional system. The plant seeds are Romaine lettuce. Each group has 15 seeds, with approximately 3 seeds for each lettuce head, resulting in 5 lettuce heads per group. The light source came from four lamps with white LED lightbulbs. Each group was separated so that there weren't extra factors that could impact the results. This experiment was conducted in the basement of a residential house since weather conditions were not suitable for outdoor experimentation.

This experiment began with purchasing three storage bins, mesh cups, and bags of nutrient mix solution. Each bin has a lid where a drill was used to insert five holes large enough for the diameter of the mesh cups to fit. Spacing out the holes was crucial because the lettuce seeds needed enough room to grow. This process was repeated two more times until each bin had 5 holes for the mesh cups to be placed in. Next, water was poured into the bin covering roughly 90% of the total volume. Since soil isn't incorporated for hydroponics, having a sufficient amount of water is necessary.

The method used for this hydroponics set-up is called Deep Water Culture (DWC). It is a simple and inexpensive practice compared to other methods. DWC revolves around the plants and their roots receiving oxygenated water mixed with a nutrient solution. For this experiment, each independent variable group had an air pump and air stone. The air pump was on the outside, charged to an outlet. Then, tubes connected the air pump to two air stones. These air stones were placed at the bottom of the bin. Oxygen was transferred by tubes from outside the bin to the inside. Bubbles were released by the airstones in the water, helping the plants develop. For the control group, two pots were placed, with 6 seeds (2 lettuce heads) in one pot and 9 seeds (3 lettuce heads) in the other. Two 1-inch holes (spaced out) were created to store the seeds. With soil, 150 mL of water was provided daily for each pot. The pots had holes with circular plates under them where some of the water would end up after seeping through the soil. The circular plates were filled with water, which had to be dumped every few days.

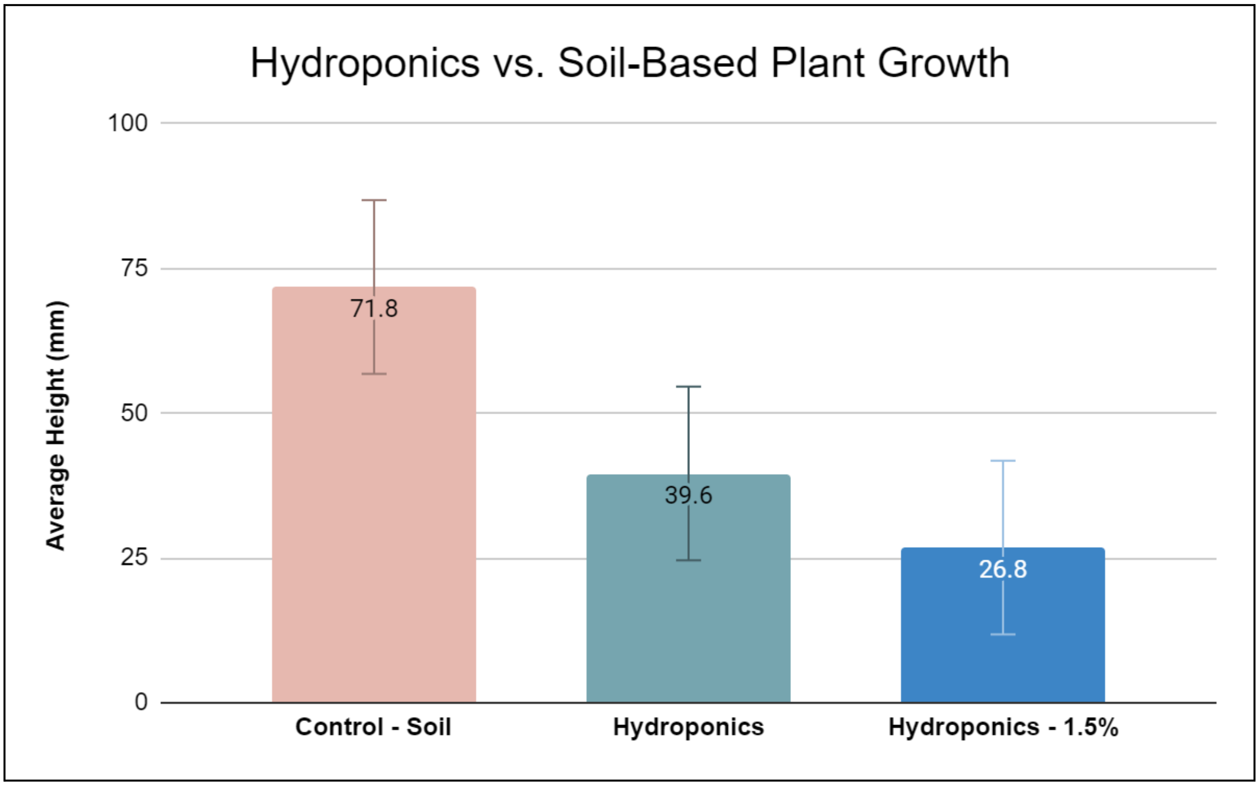
The experimentation process would last for 30 days. When it was day 15, the water in all bins was dumped and replaced with new water and the nutrient solution mix to refresh the environment where the plants grew. The plants were measured from bottom to top for plant height using a 12-inch ruler. Data was collected daily, and the information was inputted onto a spreadsheet for further analysis.

Data & Results

Table 1

Table 1: Height measured at the end of 30 days			
Height (mm)	**Control - Soil**	**Hydroponics**	**Hydroponics - 1.5%**
Trial 1	58	38	28
Trial 2	74	52	22
Trial 3	69	45	34
Trial 4	77	43	27
Trial 5	81	20	23

Figure 1

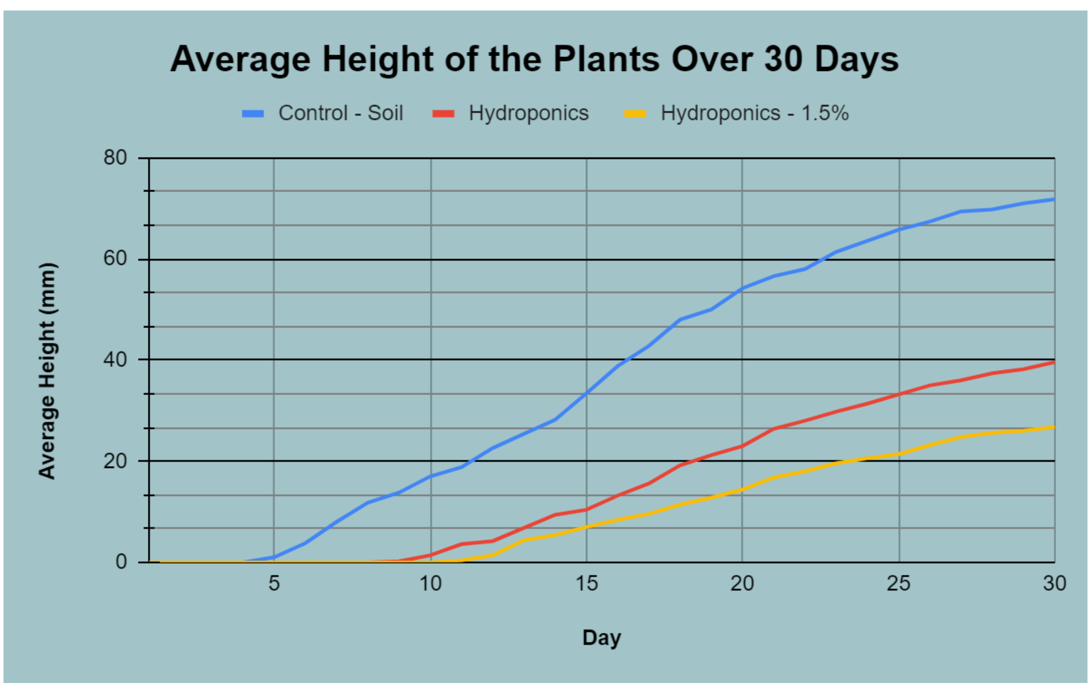


The average height of the plants with the growth bases (hydroponics and soil) at the end of 30 days is graphically represented in Figure 1, while the height of all trials is shown in Table 1. The mean height of the control group was significantly higher than all of the other hydroponic levels. The hydroponics 1.5% level represents the amount of nutrient solution used in the experimentation, as it has 1.5 times the solution compared to the other independent variable of the regular hydroponics level. The plants of the hydroponic 1.5% level were the lowest, followed by the regular hydroponics level, and the soil-based plants having the greatest height. All levels had a noticeable difference in regards to height. In addition, there were 5 trials for each level, and there weren't any major human errors that affected the end height of the plants. Hence, all of the trials can be included in the data for better accuracy. This data does not support the hypothesis that if plants are grown with hydroponics, they will grow more efficiently than soil-planting because of the usage of nutrient-based water.

Table 2

Table 2: Hydroponics vs. Soil-Based Plant Growth			
Growth Bases	**Control**	**Hydroponics**	**Hydroponics 1.5%**
Mean (mm)	**71.8**	**39.6**	**26.8**
Standard Deviation	**8.87**	**12.05**	**4.76**
1 SD (68% Band)	**62.93 - 80.67**	**27.55 - 51.65**	**22.04 - 31.56**
2 SD (95% Band)	**54.06 - 89.54**	**15.5 - 63.7**	**17.28 - 35.52**
3 SD (99% Band)	**45.19 - 98.5**	**3.45 - 75.75**	**12.52 - 41.08**
Results of t test		**t = 4.8108, p = 0.000668**	**t = 9.9926, p = 0.00001**
For all:		**significant**	**significant**
Degrees of Freedom:	**4**	**4**	**4**
Alpha = 0.05			

Figure 2



The height of the plants with the growth bases at the end of 30 days is presented in Table 1. Comparing hydroponics vs. soil with regards to the average height of the lettuce plants are summarized in Figure 1 and graphically represented over the course of this experiment in Figure 2. As indicated in Table 2, where the t-test was performed, the plants under the hydroponics 1.5% level had a significantly lower mean height (26.8 mm) than the control group (71.8 mm). The standard deviation of the hydroponic 1.5% plants were 4.76, while the control group's standard deviation was 8.87. Like the hydroponic 1.5% plants, the regular hydroponic plants also exhibited a lower mean height than the control group (39.6 mm). A one-tailed, uncorrelated, equal sample t-test was used to test the following null hypothesis at the 0.05 level of significance: the mean height of the plants in the hydroponics 1.5% group is not significantly different than the mean height of the plants with the control (soil). The same null hypothesis was used for regular hydroponics level. For the hydroponics 1.5%, $t(5) = 9.9926$, and $p = 0.00001$, and the regular hydroponics was $t(5) = 4.8108$, and $p = 0.000668$. For both t-tests, the calculated t-value was greater than the p-value, resulting in significance of data. The null hypotheses were rejected, and the alternative hypothesis: the mean height of the plants in the original hydroponics group is significantly different than the mean of the plants with the control (soil), was not rejected. Although the data was significant, it did not support the research hypothesis because both the plants in the hydroponics levels did not grow more efficiently than the control/soil-based group, as this contradicts the research hypothesis.

Conclusion

The purpose of this experiment is to answer the following research question: Which method of planting is more efficient in terms of plant growth: Hydroponics or Soil-based Planting? This experiment examines a newer or less used method (hydroponics) compared to a commonly known way (soil), which will ultimately help support the effectiveness of different agricultural practices. The experiment was maintained throughout a 30 day period where each plant was treated with the same conditions indoors, with the length of time for light exposure being constant each day. This experiment's findings are best used to provide an understanding planting methods that result in the most optimal plant growth.

At the end of the experimentation period, which was over the course of 30 days, the mean height of the control group (soil) was the highest compared to the other levels with 71.8 mm. The mean height of the plants under the hydroponics 1.5% level was the lowest at 26.8 mm. The second lowest was the regular hydroponics level, with a height of 39.6 mm. As supported by the data, the mean height of the soil-based plants was significantly higher than the other hydroponic groups. The control/soil-based group also grew more over this experimentation period as described above with the end results.

The data did not support the hypothesis that if plants are grown with hydroponics, they will grow more efficiently than soil-planting because of the usage of nutrient-based water. Even though the hypothesis wasn't supported, the data was statistically significant for all of the independent variable levels from the two t-tests that were conducted with the mean of the hydroponics 1.5% level of $t(5) = 9.9926$, and $p = 0.00001$, and the regular hydroponics at $t(5) = 4.8108$, and $p = 0.000668$. In each of these t-tests, the null hypothesis was rejected and the alternative hypothesis was not rejected.

"A research project led by horticulture specialist Dennis Pittenger investigated the effects of 15 available potting mixes from retail outlets and their abilities to support seedling growth. Of the 15 products evaluated, only three met the accepted standards for pH, salinity, and aeration after irrigation." (Vincent Lazaneo, 2015). This research project was referred to as a comparative study and supported that the materials in soil are not statistically proven to help plant growth. This conclusion was a reason for the start of this experiment to find a better, more reliable solution to plant growth. A research finding by the Department of Engineering in King Abdulaziz University (Saudi Arabia) outlined and conducted an experiment that analyzed the growth (through height) of cucumbers in both hydroponics and soil. (Gashgari et al., 2018). This research project was relevant as a comparative study because the experimentation was comparing hydroponics vs. soil-based plant growth as well. The results of that experiment were opposite of this experiment because the hypothesis supported the hydroponics system over the soil-based, while this hypothesis was not supported.

The results of the experiment concluded with the soil having the most efficiency in supporting plant growth by having the highest mean height. The hypothesis predicted that the hydroponic levels would produce the most efficient results, but that was not true in this experiment. Possibilities of error could be the rockwool used as the base of the lettuce seeds. The rockwool was bought and its material may have not been the best suitable for this experiment. In addition, the air stone and pump system for the DWC (Deep Water Culture) hydroponics may have not been large enough to fulfill 27 gallons of water for each group. The air stone and air pump were small. The soil grew well because it had a base that could support a larger root system, which is the foundation for efficient plant growth. This is proven by the end data of all of the soil-based trials and its mean being considerably higher than the other groups.

Based on findings, the research should be completed with more trials or multiple attempts at getting results for the experiment because there could be a lot of factors that affect plant growth. The light source for the experiment can be more controlled with a closer proximity between the light and the plants. Additional information, not just measured height (mm), could be accounted for so that there are multiple components to compare and analyze. For example, noticing when plants start to grow, any coloring or variations, specific features, etc., would be helpful for data documentation. More specifically, the hydroponics system can be modified so that the size of the bucket or tub with which the plants are grown in is satisfactory for the quantity of trials. This may help with water control, oxygen flow throughout the water system, and receiving enough nutrients. Potentially testing different types of hydroponic systems to see which one is most efficient for plant growth would be an adequate experiment. Furthermore, changing the composition of the nutrient solution, such as adjusting different amounts of materials that the solution contains and seeing those effects could be a continuation of this research project.

Appendix

https://docs.google.com/spreadsheets/d/1MF6gjoJmTvjD73JF8eCcGZ--xzxIMJsEkVBMoDn2p3o/edit?usp=sharing

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