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Team ID: 20644
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Challenge Division: High School

Background:

Our experiment centers around the effect of human hair mixed in with a soil blend. As a result, our independent variable is the percentage of hair added to the soil blend, and our dependent variable is the amount of growth of our plants, which is reflected in measurements of the width and length of the leaves (cm), the height of the stem (cm), and the dry mass of the plant (g). Within this experiment, we have chosen to keep a number of factors constant, including the soil blend (50/50), type of crop (Baby Bok Choy), light exposure, temperature, watering frequency, measuring frequency, type of soil, and amount of Best: Triple pro 14-14-14 plant fertilizer. This allows us to isolate the impact of increasing the concentration of human hair in a 50/50 lunar regolith and Miracle-Gro All Purpose Garden Soil mix on the growth (width, height, and weight) of Baby Bok Choy. The reason we have decided to focus on these variables is because the lunar regolith becomes more sediment as it is watered, so it starts to smother the plant's roots after a while. Human hair may be the key to preventing this by making our soil blend strong and more absorbent, acting as a cushion of sorts for the roots to grow safely. Furthermore, there are many more benefits that can be obtained from mixing human hair with soil. Human hair can be used as a natural fertilizer due to its high levels of nitrogen and other elements that can be used for nutrients by plants. Hair releases these natural fertilizers slowly during decomposition, and they could prove essential to plant growth. On top of that, human hair is also good for water absorption, which can lead to plants requiring less water in the long run. Maybe the most promising component of our experiment is the fact that human hair is completely biodegradable and always going to be available where humans are, thus making it an easy resource to travel with and have an abundance of.

As for our selection of crops, Baby Bok Choy appears to be a reliable crop with many benefits and uses. Not only can Baby Bok Choy be harvested as soon as 30-60 days after planting, but also germination occurs in a mere 7-10 days once planted. Bok Choy has a pretty basic temperature range, growing best at 64°F–68°F (18°C–20°C), but what makes it such a good crop to grow is the fact that it can tolerate temperatures as high as 95°F (35°C) and as low as 27°F (-3°C). On top of being able to withstand temperatures outside of its optimal range, bok choy is also packed with nutrients, containing vitamins A, B6 (folate), C, and K, and providing minerals such as calcium, iron, and potassium. Baby Bok Choy also grows best with a pH between 6.0 and 7.5. Our team decided to do a crop that could be harvested and consumed because that takes precedence when thinking about survival and is one of the first things that would be going to the moon. What is amazing about baby bok choy is that it is extremely versatile and can be made into a variety of dishes. Baby Bok Choy can be raw, steamed, stir-fried, grilled, or added to soups and stews. This variety not only allows Baby Bok Choy to serve its main function as a food source, but also allows it to be actually enjoyed, which, of course, is something that is extremely important to consider as well.

Experimental Design

Baby Bok Choy plants were set up inside a grow tent in the laboratory of the Career and Technical Center. In order to test the hypothesis, a number of complicated steps were taken. The control group was made by mixing the lunar regolith and the Miracle-Gro All Purpose Garden Soil in a 50/50 blend. The plants were started in a 1.5-inch seedling tray, and 40 grams of soil were used to fill the tray. A mixture of roughly 1000 mL of lunar regolith and 1000 mL of

the Miracle-Gro All Purpose Garden Soil was made in order to create a 50/50 blend of the two substances.

The next step occurred once for all five groups in the experiment: the amendment of 200 mL of water with 0.5 grams of Best: Triple Pro 14-14-14 plant fertilizer (dissolved) was added to the soil blend. This was to promote growth and ensure the plants received enough nutrients. After the soil was completed, five control groups were created in the seedling tray with the 50/50 soil blend and three baby bok choy seeds. Five control groups with just Miracle-Gro soil and five control groups with just lunar soil were additionally created.

After the controls were established, the experimental groups were created. This was done with a 50/50 soil blend, but this time only 38 grams of the mixture were measured out. After this mixture was created, 2 grams of hair were added to the mixture. This created a 5% hair and 95% soil blend mixture because 40(.05)=2, so 2 grams of hair would be needed to make up 5% of a 40-gram mixture. After this mixture of soil blend and hair was created, 200 mL of water with 0.5 grams of Best: Triple Pro 14-14-14 plant fertilizer (dissolved) was added to the soil blend one time only. Then finally, five groups of the 5% hair and 95% soil blend were added to the seedling tray.

This process was repeated until the percentage of hair reached 1.25%, creating five groups of four different mixture compositions of soil blend and hair. Each of the percentage groups was labeled based on the percentage of hair in them (e.g., 2.5% = 2.5% hair and 97.5% soil blend). The seedling trays were placed inside a grow tent, which exposed them to purple light for 12 hours and exempted them from the light for another 12. The seeds received 25 mL of water three times a week, and the pH (of the water) was measured every time before watering to ensure it fell in the 6.5–7.5 range.

The baby bok choy were also measured almost twice every week, and measurements were done by looking at the length and width of the leaves and then determining the height of the stem. Measurements were done with a standard ruler and recorded in cm. After around 3–4 weeks of germination, the plants were transferred to 6-inch pots for the continuation of their growth period. (These pots contained an amount proportional to the soil blend and percentage of human hair amendments that they were listed to be before.) The bok choy were still exposed to light for 12 hours a day and were watered with 50 mL (pH 6.5–7.5) of water. Measurements continued to be taken twice a week and in the same format (length/width of leaves and stem height).

When the growth period ended, plants were measured for leaf width, length, and stem height in order to present a final measurement. The plants were uprooted, cleaned, dried, and then measured in order to find the dry mass (in grams) of each plant. After the dry mass was determined, the collection of measurements for both pots in each group was averaged together.

Growing Set Up

Hypothesis

If a blend of lunar regolith and soil is constant at a 50/50 mix, but the concentration of human hair inside of the soil increases, then the growth exhibited by the plant will also increase.

Independent Variables

Our independent variables were the different concentrations of hair mixed into the soil, which were 1.25%, 2.5% and 5 % hair by weight.

Dependent Variables

Our dependent variable was plant growth in terms of plant height (cm) , leaf width (cm), and final dry mass (grams).

Controlled variables

Our controlled variables were consistent with the environment in which our plants were occupied with contributing factors such as the 12 hour light schedule, confined space inside a grow tent keeping the humidity and temperature of the plants consistent, and we watered the plants constantly, receiving 50 ml of water twice a week with a PH of 6.5-7.5. Other controlled variables were two soil beds- one of 100% potting soil and one with 100% lunar soil. All beds were fertilized with 0.5 grams of dissolved Best: Triple pro 14-14-14 plant fertilizer.

Control Groups

Our initial control groups for the experiment were 5 seedling pots each containing 100% potting soil, 100% lunar soil, and 50/50 mix of both. These were our control groups because they did not contain any concentration of hair.

Measurements

Measurements were taken in three ways, and the plant with the highest value for all three measuring methods was recorded in order to condense data. The three ways that measurements were taken is first, the height of plant stems were measured in centimeters, second, the width of the plant leaves were taken in centimeters, and finally, the dry weight of plants was measured in grams.

Procedure steps

1. A 50/50 mixture of lunar soil and Miracle-Gro all-purpose garden soil should be made using a 1000-liter measuring cup (1000 liters of both soils were added into a bucket).

2. 200 grams of the 50/50 mixture should be weighed using a triple beam balance and a weigh boat.
3. Add the 50/50 mixture to five different 1-inch seedling trays, each containing 40 grams.
4. After the first control is established, two additional control groups should be created with five pots each, all with 40 grams of soil:
    - One with only lunar soil
    - One with only Miracle-Gro soil
    - *(These were marked as controls due to the absence of hair.)*
5. After control groups are set, calculate the required amount of hair for each experimental group:
    - 2 grams for the 5% hair group
    - 1 gram for the 2.5% hair group
    - 0.5 grams for the 1.25% hair group
6. Multiply these amounts by five (for five pots per group), resulting in:
    - 10 grams of hair for 5% hair group
    - 5 grams of hair for 2.5% hair group
    - 2.5 grams of hair for 1.25% hair group
7. Adjust soil weights to match these hair amounts
8. Collect leftover hair from a salon.
9. Wash the hair using Dawn dish soap.

10. Dry hair using a salad spinner.

11. Once dried, pull the hair apart as finely as possible .
12. Simultaneously, measure out soil from the 50/50 blend (190 g, 195 g, 197.5 g) using a triple beam balance.
13. Add Measured soil to three different 18 quart square containers.
14. Measure dried and separated hair using a weigh boat and triple beam balance: 10 g, 5 g, and 2.5 g respectively.

15. Add correct amounts of hair to their respective soil batches and thoroughly mix.
16. Distribute hair-soil blends (5%, 2.5%, and 1.25%) evenly into 15 separate 1-inch seedling pots.
17. Add Triple pro 14-14-14 fertilizer into each of the 30 1-inch pots (the 15 experimental group pots and the 15 control groups pots)
18. Line up control and experimental groups are within the seedling tray by group.
19. Label each group with a sticky note

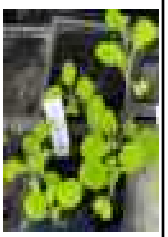
20. Add A bok choy seed into each pot.
21. Place The seedling tray in a grow tent with 12 hours of light exposure per day.

22. Water plants twice a week using a spray bottle (three sprays each time).
23. Upon germination, take measurements twice a week.
24. Midway through the growth period, transport seedlings into six-inch containers resulting in two pots per both control and experimental groups
25. Place two sprouts per container and two containers per group (both control and experimental)

26. Recalculate Soil and hair amounts for the larger containers.
27. Cut the hair into smaller pieces with scissors for smoother soil texture.
28. Plants should remain in the grow tent, receiving 12 hours of light per day and 50 mL of water twice a week.
29. After the growth period ends, carefully remove plants and place them on a paper towel.
30. Plants are left to dry for one week.
31. Measure the dry weight of each plant in grams using a weigh boat and a triple beam balance

Photos

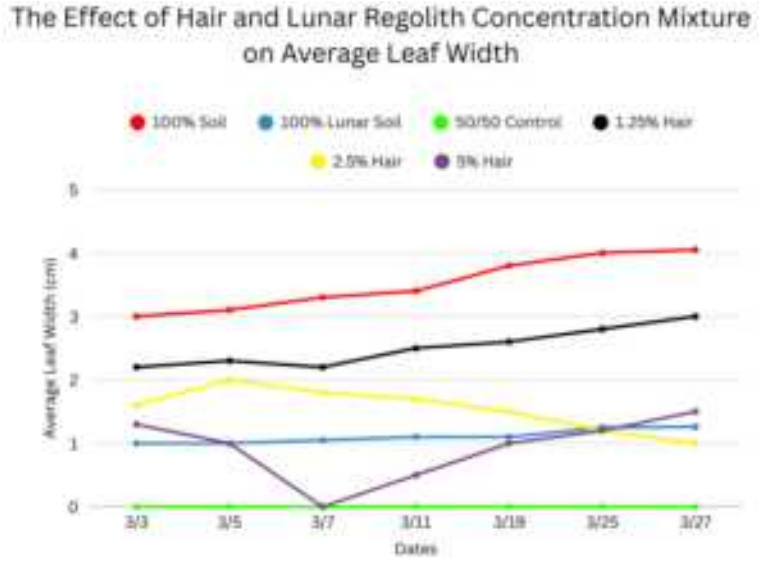
Week	100% Potting Soil (Control)	100% Lunar Soil (Control)	50/50 Blend (Control)	1.25 % Hair	2.5 % Hair	5% Hair
Week 2 ******All groups fully germinated except 2 of the 5% and 1 of 100% lunar soil.*						
Week 3 **All the sprouts started to look unhealthy.* **We transplanted 2 of each group's healthiest looking sprouts to a bigger container/pot.* **The 50/50 blend sprouts all died during transplant.* **One 100% lunar soil sprout died.*						

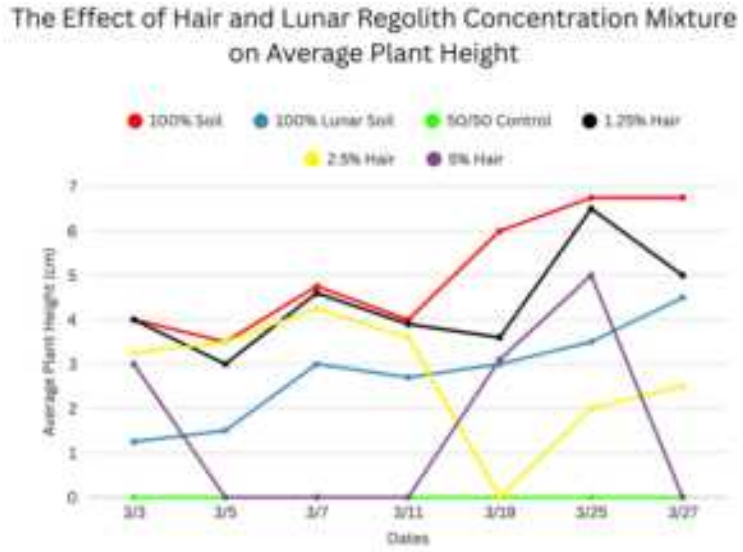
Week 4 **One 100% lunar soil sprout fully germinated.* **One 5% sprout died.*						
Week 6 **Plants look healthy.*						
Week 7 **One 5% sprout died.*						
Week 8 **One 5% sprout started growing due to stunted growth (100% germinated)* **One 2.5% sprout died.* **Control(100% soil looks healthiest).*						
						
Two weeks of data (1 and 5) were not						

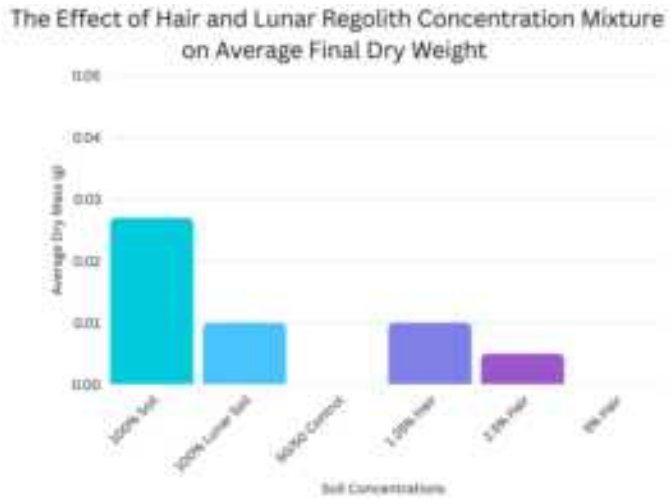
recorded due to holidays with no access to the school.						

Results

**note that no data was collected before the plants were transplanted into larger containers(week 1) and week 5 data.*







Analysis of Results

*An important note for the collected data is that, due to a number of missed school days because of snow and issues with school, there was a lack of data collection before the plants were transplanted into larger containers (week 1 and week 5 data). However, measurements were consistently taken up until just before spring break, although the plants were still watered by our teacher during that time.

For the 100% soil control, both leaf width and height consistently grew throughout the growth period according to the data, although there was a slight decrease in plant height from 3/7 to 3/11. This may have been due to plants dying internally or possibly a human error on our end. Similarly, the lunar soil also showed surprisingly consistent growth—of course, to a lesser extent than the 100% potting soil control—with the exception of a small decrease from 3/7 to 3/11 as well.

As an anomaly (of which there seem to be several in our experiment), the control group with 50% lunar regolith and 50% potting soil died, which was unexpected given the survival of plants grown in just lunar soil. Our experimental group with 1.25% hair appeared to do the next best after our 100% potting soil control group, as it also experienced growth, with slight decreases in plant height and width from 3/7 to 3/19 (height) and 3/5 to 3/7 (width).

The 2.5% hair group appeared to do slightly better than the lunar soil in the beginning, but then started to shrink at a surprisingly high rate, ultimately decreasing overall. Please note that there is a mistake in the height graph—as of 3/19, the height should be 3 cm, which still shows the 2.5% decrease in plant height.

Our 5% hair experimental group was one of the biggest anomalies in the experiment. It seemed to die from 3/5 to 3/11, but then reappeared and experienced slightly better growth than the lunar soil before dying again. This anomaly may be due to the roots remaining intact, allowing the plant to regrow.

As for the final dry weights, the 100% soil had the largest mass at 0.027 grams, with both the lunar soil and 1.25% hair soil mixture having the second largest at 0.01 grams. The 2.5% hair experimental group was the weakest, with 0.005 grams in dry mass.

Discussion and Conclusion:

Our hypothesis predicted that if the concentration of hair in a constant blend of 50/50 lunar regolith and regular soil is increased, then the amount of growth exhibited by the plants with a higher concentration of hair will also increase. This prediction was based on the background research and the assumption that, since human hair is packed with nutrients like nitrogen, it would act as a natural fertilizer. Additionally, we believed that the human hair could help aerate the soil because when lunar soil is watered, it tends to become sediment-like. However, our results and data did not support this hypothesis. The soil blend with the most amount of hair—5%—displayed the most inconsistent and unsuccessful growth pattern. While 5% initially germinated, the growth rate began to decline at week 4, with one sprout dead and both sprouts dead by week 7, although it is important to note that the 5% hair seemed to have stunted growth and "come back to life" for a short period, which appears to be an error within the experiment (maybe due to the addition of an accidental extra seed) or an anomaly (which could be due to the root system staying intact, leading to the regrowth of the plant). Similarly, in the 2.5% hair blend, one sprout died during week 6, and by the end of the growth period, only 2 sprouts survived. In contrast, the 1.25% hair blend exhibited strong growth and consistent results. All sprouts in the 1.25% group survived throughout the entire growth period, which suggests that lower concentrations of hair are more beneficial for plant growth. So it may be worth looking into in the future, as from this experiment we can conclude that instead of an increased concentration leading to more growth, there rather may be a range that is optimal for plant growth, which we believe to be the 1.25%–2.5% or even a smaller percentage (for growing baby bok choy).

Some possible sources of error with this experiment may be human error when measuring the soil and amounts of hair, as hair is very light and hard to get a direct measurement on, and it is possible that some soil may have been spilled, etcetera. There also may be some errors with the measurements regarding the growth of the plants, as the person who was doing the measurements was not consistent, which may lead to different interpretations of measurements within data or different measurements altogether. Another error is that due to the texture of hair, our group found it very difficult to mix with the soil at first (within the 1-inch pots). Although we fixed this before the transplant, the initial thickness and concentration of the hair may have stunted plant growth. Not to mention, the types of hair within our experiment were not constant, so there were different colors, textures, etcetera, which may have been a source of error if, for example, two hair textures did not work the best together. Another possible source of error is related to the 5% group, as we are not 100% sure if it was an issue on our end, or just an anomaly that was related to the root system regrowing itself. Finally, there may have been issues with transplanting the sprouts, as it is possible that their root system was damaged during the transplant, leading to overall weaker plants and lower growth rates. In the future, if expanded on, our findings could possibly help astronauts in the space station easily plant crops with something that is accessible and always available.