

# The Effect of Soil Additive on the Green Beans (*Phaseolus vulgaris*) Growth Rate vs Moon Regolith

Plant the Moon Challenge-Spring 2022



Forest Middle School Team #9317

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## **I. STATEMENT OF THE PROBLEM/OBJECTIVES:**

### **A. QUESTION TO ANSWER**

*Is it possible to grow plants in moon regolith with and without soil additives?*

## **B. PRELIMINARY OBSERVATIONS/VOCABULARY:**

The green beans were chosen not because of their nutritional value but because they interact with a certain bacteria Genus named Rhizobium. This bacterium family attaches to the roots of the legume in question. Then the bacterium will fix nitrogen into the soil and give the plant a basic food source for it to consume. This is useful for the plants because the moon regolith has little to no nitrogen in it, but the limiting factor is that the bacterium can only attach to a certain plant. These plants are called legumes.

Key terms are:

Legumes: A family of plants that are commonly referred to as beans

Regolith: The rock soil that comes from the moon that has no nutrients

Rhizobium: A family of bacteria that attaches themselves to the roots of legumes and fixes nitrogen into the soil from the air

Nitrogen: A nonmetallic gas element of Group 15 in the periodic table.

## **C. BUDGET:**

- \$400-Moon Regolith
- \$15-Soil Additive
- \$10-Planting Pots/Tray
- \$05-Distilled Water
- \$10-Graduated Cylinder
- \$25-LED Growing Light
- \$20-pH Meter
- \$10-Caliper
- \$10-Temperature/Humidity Gauge
- \$30-Latex Gloves
- \$30-Safety Goggles
- \$20-KN95 Mask
- \$05-Tablecloths (Red & Clear) & Measuring Cup
- \$50-Table
- \$25-Extension Cords
- \$20- PVC Pipe Framework
- \$15-Binder, Storage, Clipboard, Misc

**TOTAL BUDGET= \$700**

(Note: A grant was provided by the Virginia Space Grant Consortium to cover the cost of the moon regolith. All other costs were covered by community support.)

## **II. POSSIBLE SOLUTION(S)/HYPOTHESIS:**

### **A. POSSIBLE SOLUTION(S)**

*Phaseolus vulgaris* can grow in both moon regolith and moon regolith with soil additives.

### **B. HYPOTHESIS**

If *Phaseolus vulgaris* (green beans) are planted in 50%/50% regolith/soil additive, then the plants will grow 50% more in height vs the 100% regolith.

## **III. MATERIALS & LAB SAFETY:**

### **A. MATERIALS**

- *Soil additive- Dependent variable.,*
- *distilled water-was the type of water that was used to water the plants,*
- *LED growth lamps-are what had given the plants regulated light ,*
- *graduated cylinders-are what were used to measure the water amount*
- *tongue depressor-are what were used as a support beam for the green bean stalk*
- *Moon regolith-Independent variable that was used to grown the green beans.*
- *PH monitors-Used to measure the plants PH,*
- *Caliper-Used to measure growth,*
- *Table-Flat surface for the plants to sit on .*
- *Clear Shower Curtains-Used as a protection wall around the plants,*
- *Twelve 12 oz cups- pots that held the moon regolith & soil additive*
- *Extension cords-are what were used to have the LED lamp cords reach the outlet*
- *Temperature and humidity monitor-to track the data,*
- *Data tables-Location to collect the data,*
- *KN95 masks- Safety equipment to stop chemicals from being inhaled.*
- *Latex Gloves-Safety equipment to keep the skin from being irritated from the moon regolith.*
- *Eye goggles-Safety equipment to prevent chemicals from entering the eyes*
- *Tablecloth- protect table from spills.*

### **B. LAB SAFETY**

- *Safety gear was used to minimize the amount of contact between a person.*
- *No jewelry was worn during the research.*

- *Gloves, goggles, and KN95 masks were worn when working with the plants.*
- *It was insured that no playing around happened near the research*
- *It was ensured that the moon regolith was not tasted or sniffed.*
- *Additional lab safety is available here:*  
<https://ehs.okstate.edu/general-laboratory-safety-rules.html>

#### **IV. EXPERIMENTAL DESIGN:**

##### **A. SUMMARY OVERVIEW**

Green beans were planted and were given 25 mL of a day. It took about two weeks before they started to see growth in the green beans. Around the 9th week the green bean pods finally started to grow in. In the 10th week there were 6 fully grown green bean pods. Growth, temperature, humidity & pH were routinely recorded.

##### **B. VARIABLES**

Control: 100% Moon Regolith

Independent: Regolith/Soil Additive % - Co- 100/0, A-50/50, B-60/40, & C- 70/30

Dependent: Height of Growth

Constants: 25 ml water per water cycle, time of watering, days watered/week, distilled water brand, 12 hr (timer) LED light exposure, temperature, location, Wednesday pH measurement, # of pots per variable, size of pots, total volume per pot, graduated cylinder, measuring cup, 3 green bean seeds per pot

##### **C. DETAILED PROCEDURE:**

###### Pre-Growth Period:

- Application to participate in the Plant The Moon Challenge was submitted.
- Grant requests were written to support the cost of the project.
- Grant requests were accepted.
- 3 Teams were formed within the class of 30 students.
- Research was conducted to choose the plant to grow.
- Plant choice was decided.
- Supplies were purchased.
- Exolith Lab shipped the moon regolith to the school.
- Growing pod was designed and built using a table, pvc pipe, tablecloths, binder rings.
- Teacher attended the opening symposium.



###### Week 1:

- Experimental design parameters were identified.



- Proper safety equipment (KN95 masks, goggles & latex gloves) was worn.
- A large planting tray was placed in the growing pod to hold all individual pots.
- 12 pots were labeled as Co-1, Co-2, Co-3, A-1, A-2, A-3, B-1, B-2, B-3, C-1, C-2 & C-3.
- 3 lettuce seeds were planted in each pot.
- Using a measuring cup, 4 oz of 100% moon regolith was placed in A-1, A-2 & A-3 pots.
- Using a measuring cup, 4 oz of soil additive was placed in A-1, A-2 & A-3 pots.
- Using a stirring stick, the “A” pots’ soil was mixed.
- Using a measuring cup, 5 oz of 100% moon regolith was placed in B-1, B-2 & B-3 pots. Using a measuring cup, 3 oz of soil additive was placed in B-1, B-2 & B-3 pots.
- Using a stirring stick, the “B” pots’ soil was mixed.
- Using a measuring cup, 5.5 oz of 100% moon regolith was placed in C-1, C-2 & C-3 pots.
- Using a measuring cup, 2.5 oz of soil additive was placed in C-1, C-2 & C-3 pots.
- Using a stirring stick, the “C” pots’ soil was mixed.
- 25mL of distilled water was measured in the graduated cylinder. (12 times)
- 25mL of water was carefully poured into each pot.
- 30 lettuce seeds were planted in each pot.
- Extension cord for the power source was placed at the table.
- LED grow lights were plugged in and set on a 12 hour timer.
- Temperature/humidity meter was installed in the growing pod.
- Daily data was collected on plant height.
- Daily data was recorded on temperature within the pod
- Daily data was collected on humidity level within the pod.
- pH was measured and recorded each Wednesday with the pH meter.



### Week 2:

- Proper safety equipment (KN95 masks, goggles & latex gloves) was worn.
- Daily 25mL of distilled water was measured in the graduated cylinder. (12 times)
- Daily 25mL of water was carefully poured into each pot.
- Daily data was collected on plant height.
- Daily data was recorded on temperature within the pod
- Daily data was collected on humidity level within the pod.
- pH was measured and recorded each Wednesday with the pH meter.



### Week 3:

- FlipGrid video update was submitted to showcase the team and grow setup/growing pod.
- Proper safety equipment (KN95 masks, goggles & latex gloves) was worn.
- Daily 25mL of distilled water was measured in the graduated cylinder. (12 times)
- Daily 25mL of water was carefully poured into each pot.
- Daily data was collected on plant height.
- Daily data was recorded on temperature within the pod
- Daily data was collected on humidity level within the pod.
- pH was measured and recorded each Wednesday with the pH meter.



### Week 4:

- 3 teams shared an update status with VSGC thru zoom.
- Questions submitted to the Science Advisory Board.
- Proper safety equipment (KN95 masks, goggles & latex gloves) was worn.
- Daily 25mL of distilled water was measured in the graduated cylinder. (12 times)
- Daily 25mL of water was carefully poured into each pot.
- Daily data was collected on plant height.
- Daily data was recorded on temperature within the pod
- Daily data was collected on humidity level within the pod.
- pH was measured and recorded each Wednesday with the pH meter.



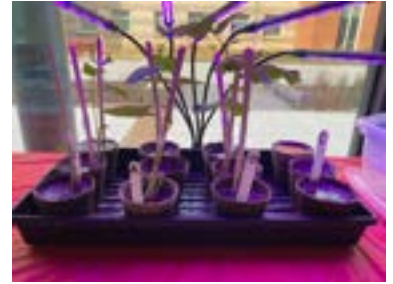
### Week 5:

- Attend Mid-Point Webinar.
- Proper safety equipment (KN95 masks, goggles & latex gloves) was worn.
- Daily 25mL of distilled water was measured in the graduated cylinder. (12 times)
- Daily 25mL of water was carefully poured into each pot.
- Daily data was collected on plant height.
- Daily data was recorded on temperature within the pod
- Daily data was collected on humidity level within the pod.
- pH was measured and recorded each Wednesday with the pH meter.
- Tongue Depressor sticks added to provide stalk support.



### Week 6:

- Daily data was collected on plant height.
- Proper safety equipment (KN95 masks, goggles & latex gloves) was worn.
- Daily 25mL of distilled water was measured in the graduated cylinder. (12 times)
- Daily 25mL of water was carefully poured into each pot.
- Daily data was recorded on temperature within the pod
- Daily data was collected on humidity level within the pod.
- pH was measured and recorded each Wednesday with the pH meter.



### Week 7:

- 3 teams presented an experiment overview to the VSGC Advisory Board.
- Proper safety equipment (KN95 masks, goggles & latex gloves) was worn.
- Daily 25mL of distilled water was measured in the graduated cylinder. (12 times)
- Daily 25mL of water was carefully poured into each pot.
- Daily data was collected on plant height.
- Daily data was recorded on temperature within the pod
- Daily data was collected on humidity level within the pod.
- pH was measured and recorded each Wednesday with the pH meter.



### Week 8:

- FlipGrid video update submitted showcasing experiment progress.
- Proper safety equipment (KN95 masks, goggles & latex gloves) was worn.
- Daily 25mL of distilled water was measured in the graduated cylinder. (12 times)
- Daily 25mL of water was carefully poured into each pot.
- Daily data was collected on plant height.
- Daily data was recorded on temperature within the pod
- Daily data was collected on humidity level within the pod.
- pH was measured and recorded each Wednesday with the pH meter.



### Week 9:

- Proper safety equipment (KN95 masks, goggles & latex gloves) was worn.
- Daily 25mL of distilled water was measured in the graduated cylinder. (12 times)
- Daily 25mL of water was carefully poured into each pot.
- Daily data was collected on plant height.
- Daily data was recorded on temperature within the pod
- Daily data was collected on humidity level within the pod.
- pH was measured and recorded each Wednesday with the pH meter.



### Week 10:

- Proper safety equipment (KN95 masks, goggles & latex gloves) was worn.
- Daily 25mL of distilled water was measured in the graduated cylinder. (12 times)
- Daily 25mL of water was carefully poured into each pot.
- Daily data was collected on plant height.
- Daily data was recorded on temperature within the pod
- Daily data was collected on humidity level within the pod.
- pH was measured and recorded each Wednesday with the pH meter.
- Final measurements were recorded.

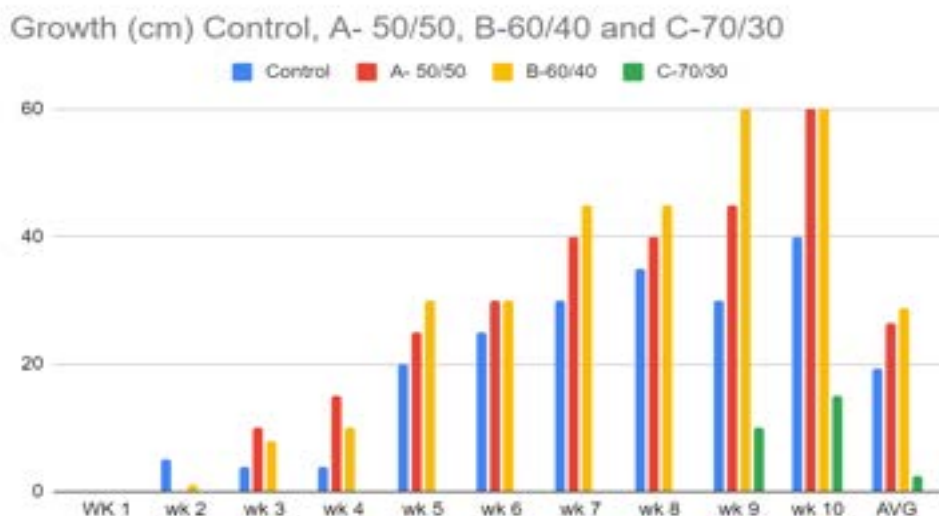


### Post Growth Period:

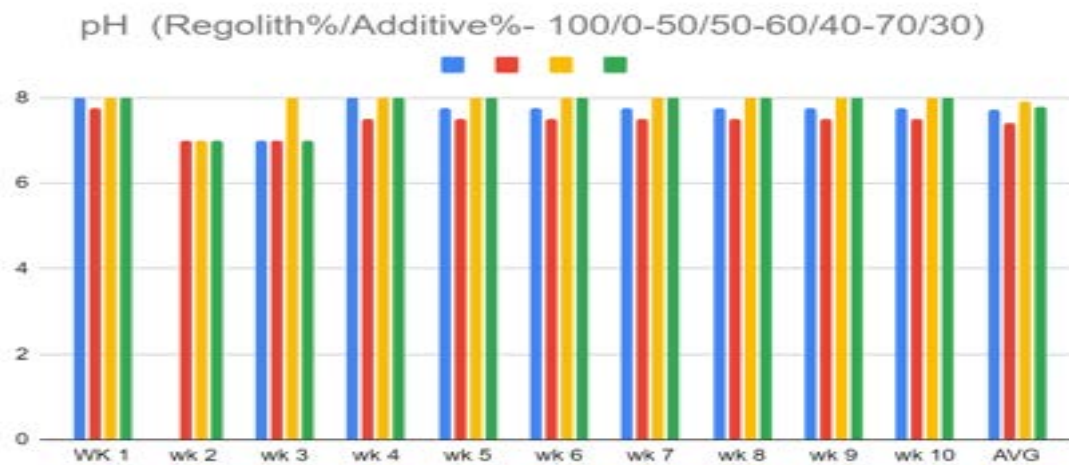
- FlipGrid video submitted summarizing the experiment.
- Final report submitted.

## **V. RESULTS (data):**

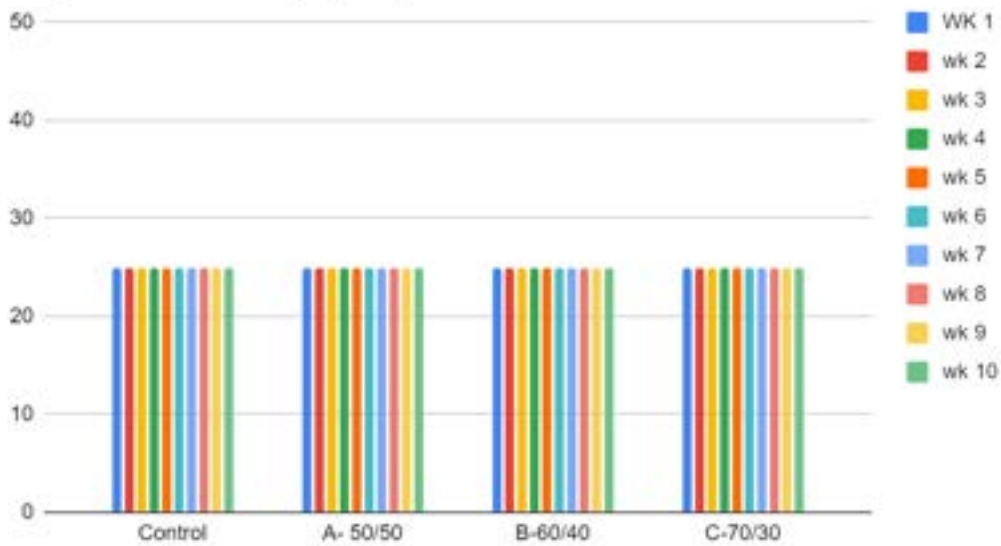
### **A. DATA TABLES:**



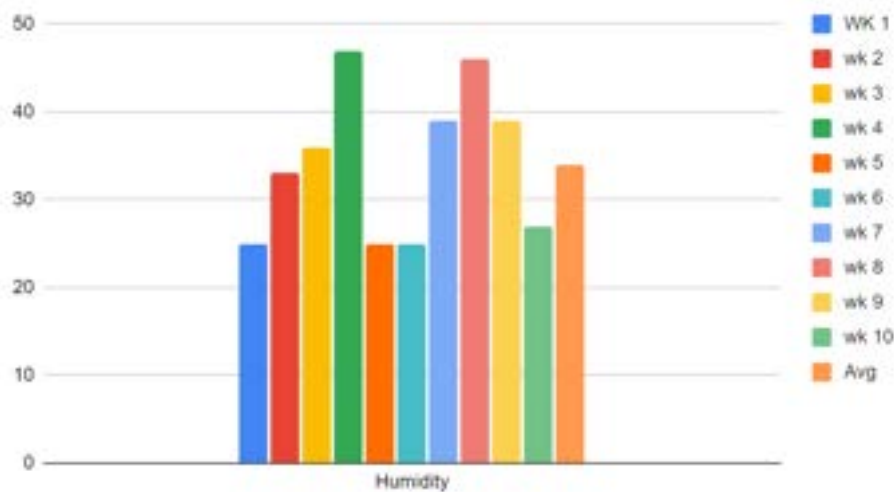




### Daily Water Average (mL)



### Weekly Humidity Averages (%)



## **B. MODIFICATIONS FOR NEXT YEAR:**

Water less and give more space so that the height of the green beans can be taller. As well as giving a better support structure for the stalks to wrap around. Also next time add a better light system along with a way to regulate heat + humidity.

## **VI. CONCLUSIONS:**

### **A. HYPOTHESIS ACCEPTANCE OR REJECTION**

The hypothesis that was made was incorrect.

### **B. WHY ACCEPT OR REJECT**

The hypothesis was rejected because the 50/50 plants did NOT grow 50% more than the 100% moon regolith/control.

### **C. DATA SUMMARY**

Growth rates for the control (100% regolith) averaged 19.3 cm, vs the 50/50 at 26.5. This was NOT a 50% increase.

pH stayed relatively constant in all the groups.

Humidity fluctuated

Surprisingly the control grew 2 green beans, 50/50 grew 3, 60/40 grew 30 and 70/30 grew 0.

### **D. REAL LIFE APPLICATIONS**

Through perseverance you will succeed, The green beans never grew until the 9th week so through perseverance they finally grew.

### **E. SOURCES OF ERROR**

- *Plants may have not gotten exactly 25 milliliters of water at each watering.*
- *Plants may have gotten over watered which can cause yellow leaves*
- *12 hour timer on lights may not have always worked 100% of the time.*
- *When recording data there may have been a mathematical error*
- *Ph might have been read wrong.*
- *Temperature was not always consistent.*
- *There might have been an error when reading the caliper*

## **VII. REFERENCES/SOURCES/CITATIONS:**

<https://www.tropicalpermaculture.com/nitrogen-fixing-bacteria.html>

<https://www.masterclass.com/articles/how-to-grow-green-beans#how-to-plant-green-beans>

<https://ehs.okstate.edu/general-laboratory-safety-rules.html>

**VIII. ACKNOWLEDGEMENTS:**

- Plant the Moon Challenge for allowing us the opportunity to participate and learn from this project.
- Virginia Space Grant Consortium for providing the grant to purchase the moon regolith and the opportunity to showcase our presentation skills.
- Forest Middle School for allowing us the platform for conducting this experiment.
- Forest, VA community for providing funding to purchase the needed supplies.
- Our teacher, Mrs. Watson, for providing guidance throughout this project.