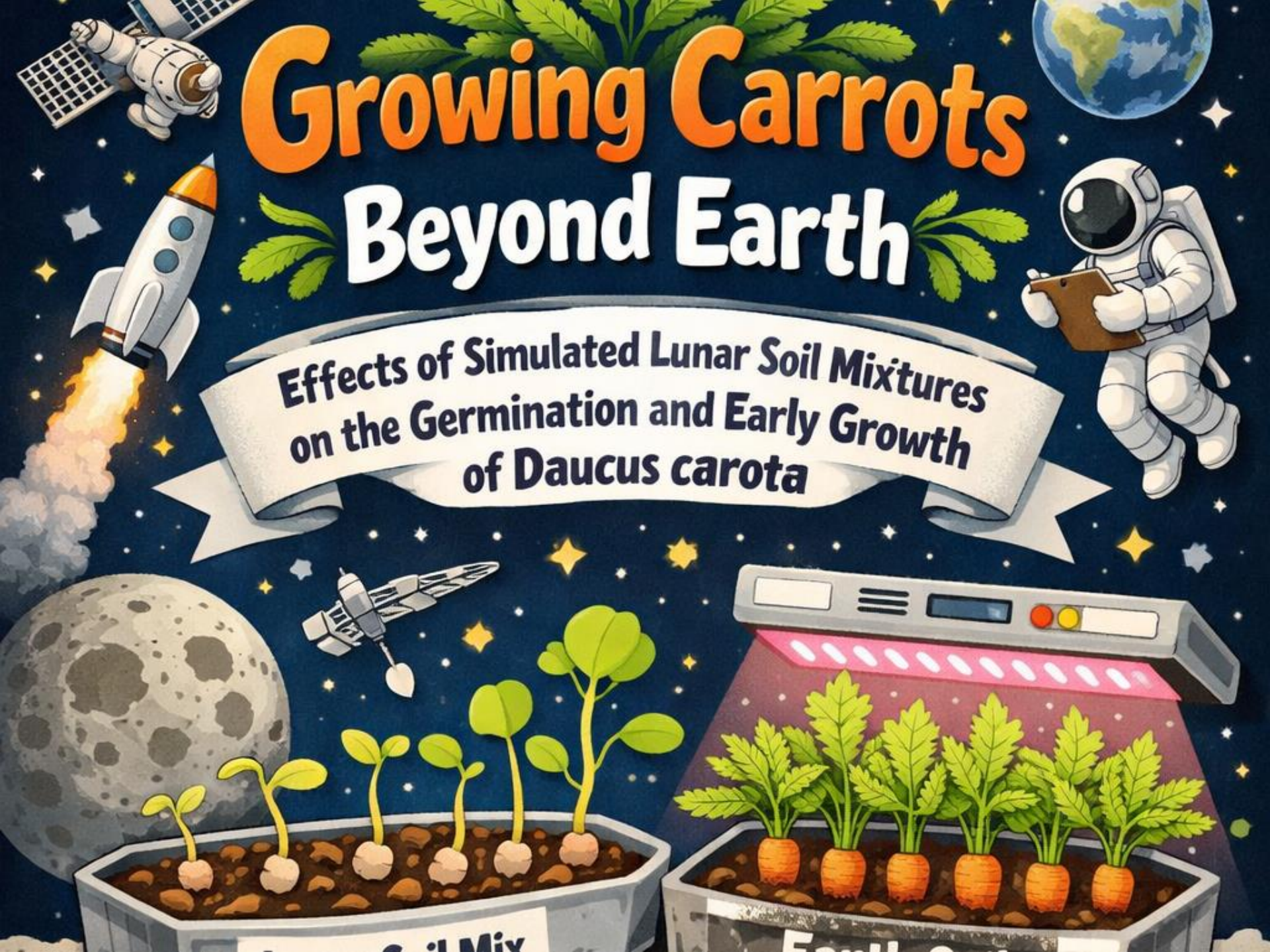
Growing Carrots Beyond Earth

Effects of Simulated Lunar Soil Mixtures on the Germination and Early Growth of *Daucus carota*



BACKGROUND RESEARCH

Importance of Space Agriculture

As space exploration advances, growing plants beyond Earth becomes essential for sustainable food production during long-term missions.

Characteristics of Lunar Soil

The Moon's surface is covered with regolith, which lacks organic matter and essential nutrients needed for plant growth.

Plant the Moon Challenge Jr.

NASA's *Plant the Moon Challenge Jr.* encourages students to investigate plant growth in simulated lunar soil, preparing them for future extraterrestrial agriculture (Plant the Moon Challenge Jr., 2023).

Previous Scientific Research

Studies show that plants can germinate and grow in lunar-like soil, although growth may vary depending on nutrient availability and soil composition (NASA, 2022; Natural History Museum, 2022).

RESEARCH GOAL

01

Investigate

- Investigate how different percentages of simulated lunar soil affect carrot plant growth by measuring final plant height.

02

Evaluate

- Evaluate whether lunar regolith–based soil mixtures can support plant growth.

03

Contribute

- Contribute to understanding sustainable food production for future space exploration.

HYPOTHESIS

Null Hypothesis (H_0)

There is no significant effect of increasing simulated lunar soil percentage on the growth of carrot plants. Changing the amount of simulated lunar soil in the planting medium will not affect the final plant height or overall growth of carrot plants.

Alternative Hypothesis (H_1)

Increasing the percentage of simulated lunar soil will affect the growth of carrot plants. Carrot plants grown in different percentages of simulated lunar soil will show differences in final height and growth performance.

RESEARCH QUESTIONS

How does changing the amount of lunar soil in the soil mix affect carrot seed germination?

How does the percentage of lunar soil affect the height and early growth of carrot plants?

Which mix of lunar soil and Earth soil provides the best conditions for healthy leaf development and overall plant growth?

VARIABLES

Independent Variable

Soil composition (ratio of garden soil to simulated lunar soil)

- Pot 1: 100% Garden Soil
- Pot 2: 80% Garden / 20% Lunar
- Pot 3: 70% Garden / 30% Lunar
- Pot 4: 60% Garden / 40% Lunar
- Pot 5: 50% Garden / 50% Lunar
- Pot 6: 40% Garden / 60% Lunar
- Pot 7: 30% Garden / 70% Lunar
- Pot 8: 20% Garden / 80% Lunar
- Pot 9: 10% Garden / 90% Lunar
- Pot 10: 100% Lunar Soil

Dependent Variable

Final Plant Height (cm)

Controlled Variables

Type of plant (carrot)

Amount of water

Light exposure

Container size

Soil volume

Growth duration

Environmental conditions

METHODOLOGY

Preparation of Pots: Ten identical planting pots were filled with soil mixtures containing different percentages of simulated lunar soil combined with Earth soil (0%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%).

Labeling: Each pot was clearly labeled according to its lunar soil percentage.

Planting Seeds: Carrot seeds were planted at the same depth in each pot.

Watering and Light Conditions: All pots received the same amount of water at regular intervals and were exposed to identical light conditions.

Monitoring Growth: Plant growth was observed daily, and leaf development and overall plant health were recorded.

Measuring Final Plant Height: At the end of the growth period, the final height of each carrot plant was measured in centimeters. These measurements provided the data for Graph 1 (Final Height per Pot).

Data Organization and Analysis:

Heights were averaged to calculate the mean plant height, displayed in Graph 2 (Average Final Height).

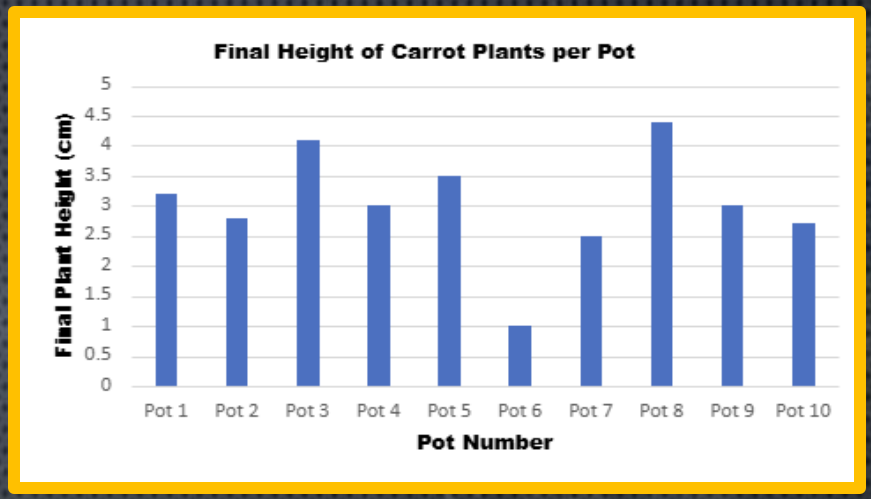
Heights were plotted against lunar soil percentages, resulting in Graph 3 (Plant Height vs. Lunar Soil Percentage).

Statistical Summary

Graphs and basic statistics were used to identify trends, variability, and correlations between soil composition and plant growth.

METHODOLOGY

RESULTS



This bar graph demonstrates the variation in plant height across individual pots.

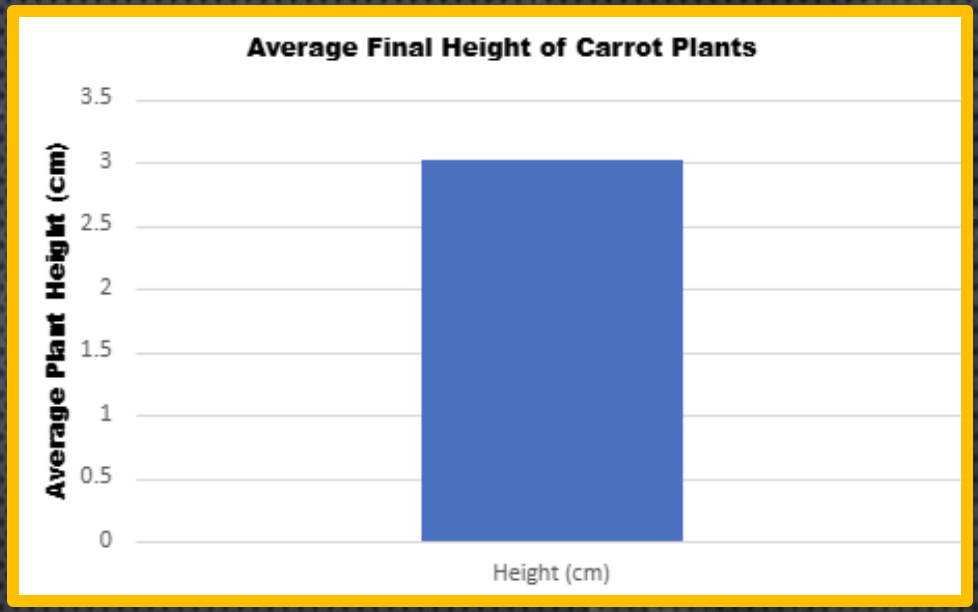
Moderate lunar soil mixtures (30%–70%) consistently produced taller plants (e.g., Pot 3: 4.1 cm; Pot 8: 4.4 cm).

High lunar soil percentages (80%–100%) showed greater variability and shorter plants (Pot 6: 1.0 cm).

The control group (0% lunar soil, Pot 1: 3.2 cm) grew well but did not surpass the moderate mixtures.

Interpretation: A moderate mixture of lunar soil and Earth soil provides optimal growing conditions, likely due to nutrient balance and improved soil structure.

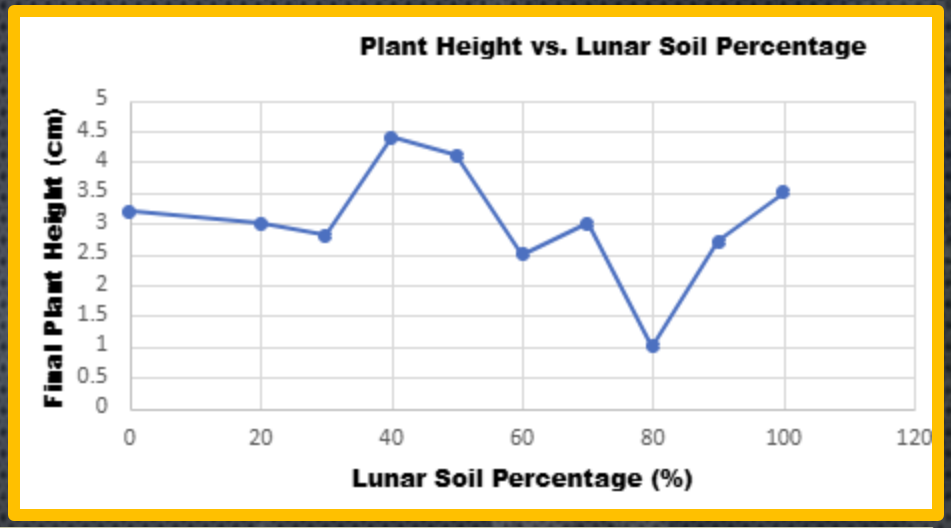
RESULTS



The overall mean final height was **3.02 cm**, indicating that simulated lunar soil, even in high percentages, does not prevent growth.

Interpretation: Despite variability in individual pots, the average height demonstrates the resilience of carrot plants and the potential feasibility of using lunar soil in extraterrestrial agriculture.

RESULTS



The scatter plot shows plant height in relation to lunar soil content:

Optimal and consistent growth occurred at **moderate lunar soil percentages (30%–70%)**

Higher lunar soil percentages (80%–100%) supported growth but with increased variability

Trendline analysis suggests a **non-linear relationship**, where growth peaks at moderate lunar soil content rather than declining linearly with lunar soil percentage

Interpretation: Soil composition affects plant growth. Mixing lunar soil with Earth soil provides the best balance for consistent growth, while 100% lunar soil may limit nutrient availability.

DISCUSSION

- Carrot plants were able to grow in all soil mixtures, including 100% simulated lunar soil; however, growth varied depending on soil composition.
- Moderate lunar soil mixtures (30%–70%) produced the tallest and most consistent plants.
- Higher lunar soil percentages (80%–100%) showed greater variability in growth, including the shortest plant observed.
- Leaf development increased with plant height, indicating healthy growth and active photosynthesis.
- The average final height across all pots was 3.02 cm, demonstrating that simulated lunar soil does not prevent germination or early growth.
- The null hypothesis, which stated that increasing lunar soil percentage would have no effect on plant growth, was rejected.
- The alternative hypothesis was accepted, as the data showed that soil composition influenced carrot height and leaf development, with moderate lunar soil mixtures producing the most optimal growth.

CONCLUSION

The null hypothesis, which stated that varying the percentage of lunar soil in the soil mixture would not affect early carrot growth, was rejected based on the data collected.

The alternative hypothesis was accepted, as carrots grown in moderate lunar soil mixtures showed successful germination and measurable early growth.

These results indicate that simulated lunar soil can support plant development and has potential for future space agriculture applications.

This study also contributes to the community and STEM education by providing a hands-on example of scientific inquiry and experimentation.

The project encourages curiosity about space science, promotes understanding of sustainable agriculture in extreme environments, and inspires future research projects in schools and local science programs.

WHY OUR RESULTS IMPORTANT

The results demonstrate the potential of simulated lunar soil to support early plant growth, contributing to sustainable space agriculture and STEM learning in the community.

Space Agriculture: The study shows that plants can germinate and grow in lunar soil mixtures, providing valuable insights for future extraterrestrial farming. Further testing with different crops may reveal broader applications for long-term human space missions.

STEM Education: Through collaborative, hands-on scientific inquiry, the study encouraged curiosity, problem-solving skills, and interest in space science among students and the community.

Sustainability and Innovation: Understanding plant–soil interactions in extraterrestrial environments can help develop strategies for growing food in extreme conditions, supporting sustainable practices both in space and on Earth.

REFERENCES

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