



HOW DO DIFFERENT REGOLITH ADDITIVES AFFECT THE GROWTH OF BEETS

A Plant Mars Experiment by the Q-36 Explosive
Space Modulators – Alison and Amber MacMillan

A Plant Mars Experiment

Introduction:

The Plant Mars challenge was started by Alison MacMillan and Amber MacMillan as we were both very interested in seeing what would happen and how cool it would be to help with space exploration and life on other planets in the galaxy. We debated on different set ups and wanted it to be as simple as possible for the astronauts. This way they would not have to spend too much of their time working with the plants and have little waste to deal with afterwards. With nitrogen being non-existent in the regolith we knew that we would need to use additives to bring that into the equation. Nitrogen is one of the top three elements essential for plant life, it needed to be added in some way or we would not have achieved any sort of plant growth.

Background:

The experiment was designed to keep things simple. The idea was that there would be minimal effort put into the upkeep of the plants in order to minimize the amount of effort required by the astronauts to recreate the results.

Experiment Design:

Four growing pots were set up with varying growing mediums in order to determine which growth additive would produce the best results. The percentage of additive to the regolith was kept the same except for in the control growing pot which had only topsoil. The growing pots were set up on a table in a sunroom that receives a small amount of eastern light, a moderate amount of western light, and a large amount of southern light. No grow lights were used. In order to keep the effort to a minimum, a bucket was set up with water in it and shoelaces were run from the bucket to the various growing pots as a watering system. The lid was placed (not closed tightly) on the bucket to minimize evaporation. This system kept a constant flow of water to the growing pots with only a weekly check on the water level in the bucket required.

The experiment was set up to determine what the best regolith additive is, and the optimal level of watering with the shoelace watering method. The value to this particular set up is that it shows which regolith additive should be focused on in additional experiments. These would allow the focus to be to determine the best percentage of regolith to additive for optimal results. There is also value in knowing the number of laces to be used in the growing pot to give an appropriate amount of water to the plants. This in turn allows for no effort when determining a simple watering system.

Hypothesis:

We believe the best additive to the regolith will be the topsoil. The topsoil used was purchased and therefore is balanced well for plant growth.

How do Different Regolith Additives Affect the Growth of Ruby Queen Beets?

Parameters:

The control growing pot was filled with purchased topsoil. The other three were filled with a mixture of regolith and additive. The pots were as follows:

- Regolith and topsoil mixture
- Regolith and bloodmeal mixture
- Regolith and decaffeinated coffee mixture

Each growing pot had 1 2/3 cup regolith and 1 cup additive.

At week 4, a new growing pot was introduced with regolith, topsoil and perlite. This consisted of 1 2/3 cup regolith, 2/3 cup topsoil and 1 cup perlite.

Ruby Queen Beet Seeds were purchased for this experiment. Beets were chosen as they are a fast-growing plant providing food from both the root as well as the greens. This means that the astronauts would not have wastage to deal with and they would have two types of edibles from each plant, the roots and the greens, providing more variety to their diets.

Dependant Variable:

We both expected the growth rate and size of the plants to be different from pot to pot. We believed that the pot mixed with topsoil and regolith would grow the healthiest and best plants because the topsoil was specifically designed for plant growth. We believed that they would all grow to some extent but that they would be different sizes and that the beets themselves would vary a little in size because of the different additives.

Measurements:

Part of the goal of this experiment was to create a relatively hands-off growing experience in order to let the astronauts focus on other aspects of their space travels. Due to this, this experiment is being completed in the same fashion. The idea is to have the astronauts only check in on the plants once a week; therefore, this experiment is being measured and reviewed only once a week.

Each week, the soil will be tested for PH balance, Nitrogen; Phosphorous; Pot Ash; number of plants; height of tallest plant in pot; and length of longest leaf. The starting measurements were as follows:

	PH	Nitrogen	Phosphorous	Potash
Regolith	7.0	< Very Low	Low	< Very Low
Topsoil	7.0	High	Very Low	Very Low
Bloodmeal	6.5	Low	Very Low	High
Decaffeinated Coffee	6.0	< Very Low	< Very Low	High

How do Different Regolith Additives Affect the Growth of Ruby Queen Beets?

Controls:

One growing pot was filled with purchased topsoil as a control. The growing pots were placed on a table in a well-lit room and were not moved. Each growing pot had five seeds planted within the pot in a circle around the perimeter of the pot. The seeds were planted one half inch deep within the pots. There will be no additional additives added throughout the experiment. This will allow any variables within the regolith mixtures to be seen and monitored which will allow any future experiments to be prepared for possible soil changes.

A self-watering system was set up allowing the watering of the growing pots to be automatic. All growing pots will have one or two shoelaces leading from the water bucket into the soil. The number will be determined based on the moisture level of the growing medium.



Week 0: Experiment setup.

Bucket with water set up on table with growing pots in front. Each growing pot has two shoelaces that have one end in the water and the other end in the growing medium.

*From Left to Right:
Regolith and Coffee, Regolith and Bloodmeal,
Regolith and Soil, Topsoil.*

Picture taken June 25th, 2021

Analysis:

Regolith/Soil Mixture Readings

Start: June 25th

	PH	Nitrogen	Phosphorous	Potash
Control (soil)	7.0	High	Very Low	Very Low
Regolith and soil	7.0	Low	< Very Low	< Very Low
Regolith and bloodmeal	7.0	< Very Low	< Very Low	Low
Regolith and coffee	7.0	< Very Low	< Very Low	High

How do Different Regolith Additives Affect the Growth of Ruby Queen Beets?

Week 1: July 2nd

Reduced to one shoelace per growing pot after measurements and pictures were taken.

	PH	Nitrogen	Phosphorous	Potash
Control (soil)	7.0	High	< Very Low	Very Low
Regolith and soil	7.5	Very Low	< Very Low	Very Low
Regolith and bloodmeal	6.5	< Very Low	< Very Low	High
Regolith and coffee	7.5	< Very Low	< Very Low	High



Week 1:

Seedlings visible in three of the four growing pots.

Excess water visible in trays beneath pots.

From Left to Right:

*Regolith and Coffee,
Regolith and Bloodmeal,
Regolith and Soil, Topsoil.*

Picture taken July 2nd, 2021

Week 2: July 9th

	PH	Nitrogen	Phosphorous	Potash
Control (soil)	7.5	High	< Very Low	High
Regolith and soil	7.5	Very Low	< Very Low	High
Regolith and bloodmeal	6.5	< Very Low	< Very Low	High
Regolith and coffee	6.5	< Very Low	< Very Low	High

How do Different Regolith Additives Affect the Growth of Ruby Queen Beets?

Week 3: July 16th

	PH	Nitrogen	Phosphorous	Potash
Control (soil)	7.5	High	< Very Low	High
Regolith and soil	7.5	Very Low	< Very Low	High
Regolith and bloodmeal	Removed from experiment			
Regolith and coffee	7.5	< Very Low	< Very Low	High

Start of new growing pot July 19th

New pot started with one shoelace.

	PH	Nitrogen	Phosphorous	Potash
Regolith, Soil and Perlite	7.0	Medium	< Very Low	Very Low

Week 4: July 23rd

	PH	Nitrogen	Phosphorous	Potash
Control	7.5	Low	< Very Low	High
Regolith and Soil	6.5	Very Low	< Very Low	High
Regolith and Coffee	7.5	< Very Low	< Very Low	High
Regolith, Soil and Perlite	7.0	Very Low	< Very Low	High

Week 5: July 30th

	PH	Nitrogen	Phosphorous	Potash
Control	7.5	Very Low	< Very Low	Low
Regolith and Soil	6.5	< Very Low	< Very Low	High
Regolith and Coffee	7.5	< Very Low	< Very Low	High
Regolith, Soil and Perlite	6.5	< Very Low	< Very Low	High

How do Different Regolith Additives Affect the Growth of Ruby Queen Beets?

Week 6: August 6th

	PH	Nitrogen	Phosphorous	Potash
Control	7.5	High	Very Low	High
Regolith and Soil	7.0	Very Low	< Very Low	High
Regolith and Coffee	7.5	< Very Low	< Very Low	High
Regolith, Soil and Perlite	7.0	High	< Very Low	High

Results:

Control	Number of Plants	Height	Leaf Length
Week 1	4	5 cm	7 mm
Week 2	4	2 inch	8 mm
Week 3	3	5.5 cm	7mm
Week 4	2	4.5 cm	10mm
Week 5	0	N/A	N/A
Week 6	0	N/A	N/A
Week 7	0	N/A	N/A

Regolith and Soil	Number of Plants	Height	Leaf Length
Week 1	5	7 cm	9 mm
Week 2	5	2 ½"	9 mm
Week 3	3	6.5 cm	1 cm
Week 4	0	N/A	N/A
Week 5	0	N/A	N/A
Week 6	0	N/A	N/A
Week 7	0	N/A	N/A

Regolith and Bloodmeal	Number of Plants	Height	Leaf Length
Week 1	0	N/A	N/A
Week 2	0	N/A	N/A

Week 3 removed this growing pot from experiment. No plant growth but worms growing in regolith mixture.

How do Different Regolith Additives Affect the Growth of Ruby Queen Beets?



Growing pot with regolith and bloodmeal mixture at week 3. Worms seen on surface of growing medium around shoelace where the moisture is predominant.

Picture taken July 16th, 2021

Regolith and Coffee	Number of Plants	Height	Leaf Length
Week 1	3	15 mm	4 mm
Week 2	3	1.5"	8 mm
Week 3	2	35 mm	3 mm
Week 4	0	N/A	N/A
Week 5	0	N/A	N/A
Week 6	0	N/A	N/A
Week 7	0	N/A	N/A

Regolith, Topsoil and Perlite	Number of Plants	Height	Leaf Length
Week 4	0	N/A	N/A
Week 5	0	N/A	N/A
Week 6	1	45mm	5mm
Week 7	1	50mm	5mm



Week 6:

Growing pot with Regolith, Soil and Perlite showing growth with two shoelaces to provide water.

Picture taken August 8th, 2021

Discussion & Conclusions:

As the experiment progressed, it became obvious that the shoelace watering system is not an ideal solution with the initial potting mediums. The first week, there were two shoelaces linked to each to each growing pot. The soil became very moist and trays beneath the pots were filled with fluids. These were a mix of water and the regolith mixtures in the growing pots. On July 2nd, the shoelaces were reduced to one leading to each growing pot in order to reduce the water. Reducing the shoelaces to one per growing pot aided with the overwatering problem.

The regolith condensed continuously in the growing pots as the weeks progressed. When the regolith samples were being taken for testing, it became increasingly difficult to loosen adequate amounts of regolith mixtures.

Plants began to grow in the regolith and soil mixture as well as the regolith and coffee mixture. By week 4, all of these plants had died. Due to the condensing of the regolith over time, it was surmised that the plant roots could not adequately penetrate, killing the plants.

With this observation, at week 4, a new growing pot was setup with regolith, soil and perlite to add additional looseness to the regolith mixture. This growing pot was started with one shoelace for watering. The mixture proved to be very different from the other growing pots as the water was not penetrating into the regolith mixture. At week 5, a second shoelace was added to increase the water. This resulted with a single plant by week 6. The growing medium in this pot did not condense to the same extent as the others and two shoelaces were continued throughout the remainder of the experiment time with this growing medium. Two shoelaces did not produce an overwatering situation with this regolith mixture.

How do Different Regolith Additives Affect the Growth of Ruby Queen Beets?

The control growing pot meanwhile, showed that even a single shoelace to topsoil without additives provides too much water. The soil became increasingly wet with every week. By the conclusion of the experiment on August 9th, the topsoil was wet enough to have a consistency more like mud. This could explain why the four plants that had started growing within the control pot, were all dead by week 5.

These results show that the shoelace watering method is not necessarily ideal for growing plants within the Mars regolith. It would take a great deal of experimentation in order to determine an appropriate ratio for shoelaces to growing pot size. The width and depth would have to be taken into consideration as the regolith is dense enough to impede adequate distribution of water throughout the growing medium.

This experiment has also shown that a mixture of regolith and bloodmeal will not produce plant life on Mars, but further experimentation could be completed to determine if this is a possible way to bring insect and/or invertebrate life to the planet to help with improving growing conditions on site.

References:

Can you use coffee grounds to fertilize indoor plants? Smart Garden Guide. (2019, September 5). <https://smartgardenguide.com/coffee-grounds-fertilize-indoor-plants/>

Zimmer, F. (2021, August 6). *Do indoor plants like coffee grounds?* Indoor Plants for Beginners. <https://www.indoorplantsforbeginners.com/do-indoor-plants-like-coffee-grounds/>

EspirituFounder, K. (2020, January 23). *How to add blood meal to your garden soil.* Epic Gardening. <https://www.epicgardening.com/blood-meal/>

1st ZOOM meeting for the Plant Mars Challenge (2021, June 3)