



# Martian Seed Experiment

What happens when Red Stem Spinach is exposed to Mars like conditions.

## INTRODUCTION

You are a NASA Astro-Botanist (like Mark Watney in the movie *The Martian*) and you have been asked to determine if vegetable seeds can withstand the harsh conditions on Mars. It's likely that the first astronauts visiting Mars (NASA is planning the first mission for 2024!) will have to grow their own food. What would happen if the seeds that they bring are exposed to the Martian atmosphere? Will they still grow? Will the vegetables and fruits they produce be edible? You have been asked to find out.

## HYPOTHESIS

From what you currently know, you believe that seeds can survive short durations (3 hours or less) of exposure to Martian conditions including:

- a) Very low temperatures (down to minus 50 degrees F).
- b) Very high doses of UV radiation (30 x greater than at the Earth's surface).
- c) Very low atmospheric pressure (~ 0.162 psia).

To test your hypothesis, you will carry out the following experiment.

## DESIGN OF EXPERIMENT

Red Stem Spinach seeds will be divided into several groups for you: a control group (**Group 0**) as well as the groups listed below. All of these groups, except the control group, will be flown in the payload of a High-Altitude Balloon (HAB) here on Earth. The HAB will reach an altitude of approximately 20 miles. At this altitude the conditions are similar to that found on the surface of Mars (see above). By positioning the seeds appropriately in the HAB payload box they will be exposed to varying conditions as indicated below:

**Group 1** – will be placed on the outside of the payload box exposing the seeds to low temperature, low atmospheric pressure, and high UV radiation.

**Group 2** – will be placed inside the payload box exposing the seeds to low temperature and low atmospheric pressure.

**Group 3** – will be placed inside the payload box attached to a hand warmer countering the low temperature expected and exposing the seeds to just low atmospheric pressure.

During the flight sensors aboard the HAB payload will collect and transmit to ground stations the following data at one-minute intervals:

- Temperature.
- Atmospheric pressure.
- Altitude.
- GPS coordinates.
- Relative humidity.

## MATERIAL LIST

The following materials are needed for the post flight procedures of this experiment:

1. Red stem spinach seeds (*spinacia oleracea*) (provided)
2. Small pots (provided)
3. Potting soil (student must provide)
4. Ruler marked in millimeters (student must provide)
5. A water proof marker pen to label the pots (student must provide)
6. Water

After the flight of the HAB, the seeds will be delivered to you. You will plant them and monitor their growth according to the following protocol. The article included in Appendix B provides further information describing how to grow spinach:

1. Plant five (5) seeds, from each group, individually in the pots provided using standard potting soil. You should end up with 20 pots (5 seeds x 4 groups). Follow the planting instructions provided in Appendix B.
2. Label all of pots with their Group # and Pot # and place them outside in a sunny or mostly sunny location. (Example: G1P1).
3. Check the soil and water each pot as necessary to keep it moist every other day.
4. Make the following observations for each pot every seven days, over a period of 50 calendar days, and write down your observations in the tables provided in Appendix A:
  - a. What group is being observed? What Pot #?
  - b. What is the current date and time?
  - c. Has the observed seed germinated yet?

- d. After the seeds have germinated – what is the plant’s height? (use a ruler to measure the height above the soil line in millimeters).
- e. Compared to the picture below – do the leaves appear to be “normal”? What is different if anything?
- f. Compared to the picture below – do the stems appear to be “normal”? What is different if anything?
- g. After 50 days, harvest the leaves and stems. Note any differences that you see between the groups.

## PICTURE OF HEALTHY RED STEM SPINACH PLANT GROWN ON EARTH



## EXPERIMENT COMPLETION

Please scan and email the completed forms from Appendix A to [richard@scienceheads.org](mailto:richard@scienceheads.org). Once the data from all of the experimenters is compiled it will be summarized and emailed back to you.

## SUPPORT AND BACKGROUND

If you have any questions about this experiment please send them via email to [richard@scienceheads.org](mailto:richard@scienceheads.org). Please refer to the instructions provided in Appendix B for answers about growing spinach.

This experiment is being conducted as part of the Science Heads Inc. High Altitude Research Project (HARP). This project is designed to give students the experience of conducting a real-world experiment and apply what they have learned about scientific methodology and the various STEM subjects they have studied in school.

Science Heads Inc. is a 501(C)(3) non-profit organization whose mission is to support STEM education and raise science literacy. Additional information about Science Heads and its HARP program is available at [www.ScienceHeads.org](http://www.ScienceHeads.org).

## **APPENDIX A**

Data entry forms:

Group 0 - Control Group (nominal Earth temperatures, atmospheric pressure, UV).

Group 1 - low temperature, low atmospheric pressure, and high UV radiation.

Group 2 - low temperature and low atmospheric pressure only.

Group 3 - low atmospheric pressure only.

## Group 0 – Control Group (nominal Earth temperatures, atmospheric pressure, UV)

Observation Day	Pot #	Date MM/DD/YY	Time 00:00 AM/PM	Germinated? (Yes/No)	# Days Since Planting	Height (mm)	Leaves Appear Normal (Yes/No)	Stems Appear Normal (Yes/No)	General Observations
1	1								DAY OF PLANTING
	2								DAY OF PLANTING
	3								DAY OF PLANTING
	4								DAY OF PLANTING
	5								DAY OF PLANTING
2	1								
	2								
	3								
	4								
	5								
3	1								
	2								
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	4								
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6	1								
	2								
	3								
	4								
	5								
7	1								DAY OF HARVESTING
	2								DAY OF HARVESTING
	3								DAY OF HARVESTING
	4								DAY OF HARVESTING
	5								DAY OF HARVESTING

**Group 1 - low temperature, low atmospheric pressure, and high UV radiation.**

Observation Day	Pot #	Date MM/DD/YY	Time 00:00 AM/PM	Germinated? (Yes/No)	# Days Since Planting	Height (mm)	Leaves Appear Normal (Yes/No)	Stems Appear Normal (Yes/No)	General Observations
1	1								DAY OF PLANTING
	2								DAY OF PLANTING
	3								DAY OF PLANTING
	4								DAY OF PLANTING
	5								DAY OF PLANTING
2	1								
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6	1								
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	5								
7	1								DAY OF HARVESTING
	2								DAY OF HARVESTING
	3								DAY OF HARVESTING
	4								DAY OF HARVESTING
	5								DAY OF HARVESTING

## Group 2 - low temperature and low atmospheric pressure only.

Observation Day	Pot #	Date MM/DD/YY	Time 00:00 AM/PM	Germinated? (Yes/No)	# Days Since Planting	Height (mm)	Leaves Appear Normal (Yes/No)	Stems Appear Normal (Yes/No)	General Observations
1	1								DAY OF PLANTING
	2								DAY OF PLANTING
	3								DAY OF PLANTING
	4								DAY OF PLANTING
	5								DAY OF PLANTING
2	1								
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6	1								
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	5								
7	1								DAY OF HARVESTING
	2								DAY OF HARVESTING
	3								DAY OF HARVESTING
	4								DAY OF HARVESTING
	5								DAY OF HARVESTING



### Group 3 - low atmospheric pressure only.

Observation Day	Pot #	Date MM/DD/YY	Time 00:00 AM/PM	Germinated? (Yes/No)	# Days Since Planting	Height (mm)	Leaves Appear Normal (Yes/No)	Stems Appear Normal (Yes/No)	General Observations
1	1								DAY OF PLANTING
	2								DAY OF PLANTING
	3								DAY OF PLANTING
	4								DAY OF PLANTING
	5								DAY OF PLANTING
2	1								
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6	1								
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7	1								DAY OF HARVESTING
	2								DAY OF HARVESTING
	3								DAY OF HARVESTING
	4								DAY OF HARVESTING
	5								DAY OF HARVESTING

## APPENDIX B

### How to Grow Spinach in Pots | Growing Spinach in Containers & Care

From:

<https://balconygardenweb.com/how-to-grow-spinach-in-pots-growing-spinach-in-containers-care/>

Learn **how to spinach in pots**, it is one of the vegetables that you can grow in some shade. **Growing spinach in containers** is easy too you can even grow it indoors on a windowsill.

**USDA Zones**— 3 - 11

**Difficulty**— Easy

**Other Names**— Spinacia oleracea (Scientific Name), Persian vegetable, palak, bōsī cài, 波斯菜, leafy greens

#### How to Grow Spinach in Pots

##### Growing Spinach in Pots from Seeds

Sow seeds 1/2 inches deep directly in containers or a seed tray. Seedlings will germinate in 5-14 days depending on the variety and growing conditions. If you have sown seeds in a seed tray wait until 2-3 true leaves appear on each plant and then transplant them into the original pots carefully.

##### Choosing a pot

For growing spinach in pots, choose a pot that is least 6-8 inches deep. You don't need a very deep pot rather use a wide pot. You can either use so many small pots and grow one plant in each or select large window boxes, wooden boxes or crates.

##### Spacing

Provide each spinach plant a space of 3 inches, if you want to pick large leaves, give more space to each plant, 5 inches. If you want to harvest leaves at very young age, then the spacing can be reduced to 2 inches only. Divide the planter box into squares, and see how many plants will feel comfortable in it.

#### Requirements for Growing Spinach in Containers

##### Position

If you are growing spinach in fall (autumn), keep the plant in a sunny spot (in mild climates) due to shorter days and less intensity of the sun. For spring and summer planting keep your potted plants in a location where it receives some shade, especially in the afternoon. In subtropical or tropical climate, place the containers in a spot that receives plenty of shade.

##### Soil

For growing spinach in containers, use quality potting mix rich in organic matter. The texture of soil must be crumbly and loamy. Avoid soil that clogs the drainage and remains waterlogged. Well-draining soil is most important factor for the optimum growth of spinach in containers. Soil pH must be neutral.

##### Watering

When growing spinach in containers, avoid water stagnation because it will lead to the development

of rot and various fungal diseases. Also, avoid wetting the foliage. Keep the soil moist but not soggy or wet. Taking care of good drainage in the pot is necessary.

## Temperature

Spinach seeds germinate in temperatures as low as 40 F (4 C) and in high temperatures too. The best soil temperature for growing spinach falls in the range of 50-80 F (10-27 C). Many spinach cultivars can tolerate temperature down to 20 F (-6) and up to 90 F (32 C) easily. Once the temperature starts to soar high, you may need to provide shade to your plants.

## Growing Spinach Indoors

Growing spinach indoors on a windowsill is a great idea (as it doesn't require a lot of sunlight) if you're short of outdoor space. For this, buy a few 6 inches deep small pots and grow spinach in them. You can also grow herbs and annual flowers there.

## Spinach Care

*Growing spinach in pots* doesn't need special care. Regular watering, fertilizing and the right soil is the key to the great harvest.

## Fertilizing

For growing healthy green spinach, you have to provide nitrogen. At the time of planting, you can mix time-based fertilizer, or you can add a lot of compost or well-rotted manure, this will provide nutrients slowly. Feeding the plant with fish emulsion, compost or manure tea in the middle of the growth and so on is a nice organic way to promote the plants. If you have not done added time-based fertilizer, you can also feed the plant with balanced liquid fertilizer at regular intervals.

## Mulching

Do mulching, even if you're growing spinach in pots. Mulching plants with organic matter will help in retaining moisture.

## Pests and Diseases

You don't need to worry much about pests as you're growing spinach in containers, in a small space and you can easily control them. However, keeping an eye on leaf-eating insects like slugs and caterpillars and other common garden pests like aphids will help you in eliminating them in time.

## A Few Tips for Growing Spinach in Tropics

It is a cool season crop, but **growing spinach in tropics and subtropics** is extremely easy. Moreover, you can grow it successively as a bi-annual crop, except in hot summer months. You'll need to provide it shade and enough water to keep the soil temperature cool and moist. In warm weather, vegetables like lettuce and spinach begin to bolt early and start to set seeds. One of the most important things you need to consider when growing spinach in tropics is to grow heat tolerant varieties (there are a lot of Asian varieties that are suitable for tropical climate) that grow slowly and do not bolt quickly. These varieties easily tolerate the heat and humidity.

## Harvesting

The spinach plant will be ready for harvest 37-50 days after germination depending on the growing conditions and cultivar.

Harvesting can be done when the plant has formed at least 5-6 healthy leaves, and they are at least 3-4 inches long. Pick outer leaves first and leave the new inner leaves so that they continue to grow or cut the whole plant off at the base with a knife or scissor, the plant will resprout again. When the weather becomes humid and hot (in warm climates) the plant tends to form an erect stem, on which you can see some small yellow or green flowers developing. To coincide with the flowering and the subsequent production of flowers, the foliage of the plant thickens and changes in flavor (more bitter), which is called bolting, so it is convenient to harvest the plant before it starts flowering for better taste.