Farming in Space?

Developing a Sustainable Food Supply on Mars

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Problem Statement

Congratulations! You are leaving Earth forever. You are selected to be part of a mining colony of 100 people located on the planet Mars. Before you head to Mars, however, you need to figure out how to feed yourself and your colleagues once you are there. Your group is tasked with selecting the foods to be grown on Mars.

Suppose that enough food can be taken to supply the entire colony for several months (approximately 90 days). After this, food for the colony must come from what can be grown. The colony manager is instructed to keep costs as low as possible while still providing a sustainable food supply that meets the nutrient requirements for adult humans. You may assume that all of the colonists are healthy adults of average height and weight with no known food allergies.

By the time you arrive on Mars, a dome-like structure will already be in place to maintain an Earth-like air composition, pressure, and temperature. Within this dome there are 1000 acres available for growing foodstuffs. You can bring seeds, soil, and fertilizer with you, but keep in mind that seeds require time to germinate and grow to maturity, and different plants have different growth requirements. Additionally, certain foodstuffs require more fertilizer than others, which is additional weight you must bring with you, increasing the cost of the trip.

Some Mars facts: Mars has a 687d orbital period and a 24h 40m day-night cycle, and sunlight is about 44% as intense as at Earth. Mars has plenty of carbon dioxide and water for your use, but you will still need to collect it and recycle all that you use. The soil and air are extremely poor in carbon and nitrogen compounds, hence the need for fertilizers and other organics. Outside of your dome, the air pressure will be at most about 1% that at Earth's surface. The outside day-night temperature will vary by 60 to 80°C, with a daytime maximum above the freezing point of water during the summer. Martian-analog soils on Earth would include those of the ash-infused Columbia plateau in North America, and the Dry Valleys of Antarctica.

Your problem-solving method will proceed thus:

- In Part I, you will identify some potential challenges related to sustainable agriculture.
- In Part II, you will choose *five* criteria to be used for ranking potential Martian crops.
- In Part III, you will use your criteria to rank a list of given crops and identify the top *three*.
- In Part IV, you will reflect upon the context of the problem, the method of solution, and the results, and thereby identify strengths and weaknesses.

Part I – Sustainability Considerations

In an inhospitable environment such as the Martian surface, sustainability becomes a major issue. Sustainability implies that whatever resources are used to grow crops (e.g., water, fertilizer) can be replaced so that the growth of crops can continue, producing the same quantity and quality of crops indefinitely.

Questions

1. As a group, write down two challenges in terms of sustainability you would face when developing a sustainable food supply for a Martian colony (or any area that is severely lacking in agricultural resources). Keep in mind the space and time limitations you have (1000 acres of growing space and several months' worth of food).
2. A sustainable food supply requires more than just resource management. It also needs to provide people with sufficient calories, macronutrients, and micronutrients for health, productivity, and well-being. Write down at least two challenges of producing such a diet sustainably in an area severely lacking in agricultural resources.

Part II – Selecting Criteria for Growing Foods

From the list below, choose the five *most important* criteria for selecting appropriate foods to grow in the Martian colony, keeping in mind the constraints given in the problem statement and your responses to the previous questions. Write a paragraph justifying *why* these five are the most important.

- Water usage
- Fertilizer usage
- Space required for growth
- Yield
- Post-harvest processing required
- Waste generation
- Total kilocalories provided
- Protein content
- Carbohydrate content
- Fat content
- Micronutrient content
- Additional structure needed for growth/processing/storage
- Time to grow to harvest
- Labor/fuel required for growth/processing
- Shelf life after processing

Part III – Foodstuff Selection

After discussing colony needs and constraints with specialists in plant and soil science, you have generated a list of foodstuffs that could potentially be grown on Mars:

- Corn
- Rice
- Oats
- Barley
- Potatoes
- Wheat
- Peas
- Soybeans
- Peanuts
- Spinach
- Broccoli
- Winter squash
- Fish

Using the tables below, select the three foodstuffs that are *optimal* as determined *from the five criteria you chose in Part II*. Ignore the other criteria when making your selection. Possible scoring systems include (but are not limited to) assigning more weight to criteria that are considered more important or assigning different numbers of points to different categories (e.g., high=1, medium=2, low=3).

If the criteria you select result in more than three optimal foodstuffs based on your scoring system, you must determine and justify a way to break any tied scores. Write a paragraph identifying your three chosen foodstuffs and justifying why they are the most appropriate to grow on Mars.

	Water usage	*Fertilizer usage*	*Space required for growth*	*Yield*	*Post-harvest processing*	*Waste generation*	*Time to grow to harvest (fast growth: low)*	*Labor required for growth & processing*
Corn	Medium	High	High	High	Medium	High	Low	Medium
Rice	High	High	High	Medium	High	Medium	Medium	High
Oats	Low	Low	High	Low	High	Medium	Low	Medium
Barley	Low	Medium	High	Low	High	Medium	Low	Medium
Potatoes	Medium	High	Medium	High	Low	Low	Medium	Low
Wheat	Low	Medium	High	High	High	Medium	High	High
Peas	Low	Low	Low	Medium	Medium	Medium	Low	Low
Soybeans	Medium	Low	Low	Low	Medium	Medium	High	Low
Peanuts	Low	High	Medium	Low	Medium	Medium	High	Low
Spinach	Medium	High	High	Low	Low	Low	Low	Medium
Broccoli	Medium	High	High	Low	Low	Low	Low	Medium
Winter squash	High	Medium	High	Low	Low	Low	Medium	Medium
Fish	High	Low	Medium	Low	High	Medium	High	High

	Total calories provided	*Protein content*	*Carbohydrate content*	*Fat content*	*Micronutrient content*	*Additional structure needed for growth, processing, storage*	*Shelf life after processing*
Corn	High	Low	High	Low	Medium	Medium	High
Rice	Medium	Low	High	Low	Medium	Medium	High
Oats	Medium	Low	High	Low	Medium	Medium	High
Barley	Medium	Low	High	Low	Medium	Medium	High
Potatoes	Medium	Low	High	Low	High	Medium	Medium
Wheat	Medium	Medium	High	Low	Medium	Medium	High
Peas	High	Low	High	Low	High	Low	High
Soybeans	Medium	Medium	Medium	Medium	High	Low	High
Peanuts	High	Medium	Medium	High	High	Medium	High
Spinach	Low	Low	Low	Low	High	Low	Low
Broccoli	Low	Low	Low	Low	High	Low	Low
Winter squash	Low	Low	High	Low	High	Low	Low
Fish	High	High	Low	Medium	High	High	Low

Part IV – Reflection

Discuss the following questions with the members of your group. Choose someone in your group to take minutes of the discussion.

Questions

1. In reference to Part II, are there criteria *not* listed that you would add to the list? If so, what would you add? Would these criteria be ranked among your top five? If so, then justify your choice.
2. In reference to Part III, are there foods *not* listed that you would add to the list? If so, explain why you would add these foods to the list and estimate values (high, medium, low) for each criterion. Include a formal reference to any information you have to look up. If you think the list is complete, explain why.
3. Consider your three best foods: could you survive indefinitely on this diet? Be productive and healthy? Be happy? Why or why not?
4. Why do you think your group was restricted to only three foods?
5. How do you think your final list of three foods would change if you included more than five criteria for ranking each food?
6. Would you grow additional types of foodstuffs after developing the infrastructure to sustainably produce your three chosen foods? Explain your answer.
7. Part II lists 15 criteria for ranking foods. Which of these criteria are related to sustainability? Justify your selections.