**Could plants have actually grown plants on 3% nutrient levels?**

**Teacher Alert:** The source of nutrients in *The Martian* is human feces. Some “candid” discussion about the topic may be needed.

**Background:** The human digestive system, as for all animals, has evolved to extract nearly all of the nutrients in the consumed food. As a result, feces are actually very low in nutrient concentration (which incidentally is a major challenge in widespread “organic” crop production). Based on the potato production system in *The Martian*, it appears that nutrient supply to Watney’s potato crop would have been no more than 3% of what would have actually been required for full-season growth. In this exercise, only the initial phase of plant response to low nutrients will be observed.

 While potato can be used in this exercise, we used maize (sweet corn) seed since the experiment can be done in smaller containers.

*Educational Opportunities*

A. Learn about assembling an experiment and maintaining a record of observations.

B. Learn about hydroponic approach to supplying nutrients and growing plants.

C. Learn about the essential need for nutrients in growing plants.

*Materials and Experimental Environment*

* Maize seeds (alternatively seed potatoes)
* Sand: if possible, purchased construction or playground sand, which would be low in nutrients.
* Nutrient source: Household fertilizer mix (we used Miracle-Gro All Purpose Plant Food) or hydroponic mix.
* Containers in which to mix the fertilizer solutions (we provided the solutions to the students).
* Saucers (e.g. aluminum pie plates) on which to place containers to catch drained water
* Volumetric cylinders to add nutrient solutions and water to pots.
* Sunny location to place pots.

*Procedures* (The material in the box below can be put on the blackboard for students to copy into her/his notebook.)

1. Each laboratory group (2-4 students) prepare a ‘pot’ for each of the nutrient treatments.

a. We used 1-L water or soda bottles that had been rinsed clean.

b. Carefully cut the bottle to create a 25-cm tall pot. We precut the bottles so the children did not have to use "sharps".

 b. Drill or poke small holes (~ 3-5 mm diameter) in bottom of containers to allow drainage

2. Fill each container with sand to about 20-cm depth, gently packing the sand. Sow three seeds in each pot to a depth of about 3 cm. Children “calibrated” their fingers for the 3-cm depth.

3. Add water in about ~25 mL increments until there is drainage from the pot. (Likely roughly 200 mL per pot.)

4. Place pot on saucers in sunny location.

5. After seedlings have emerged to about 2 cm, nutrient solution is added to each pot. The teacher will likely make nutrient solutions (Miracle Gro recommended 1 tsp per gallon). The children will add 20 mL of the appropriate nutrient solution to each pot.

 a. *The Martian* concentration: Make solution 3% of recommended concentration.

b. Deficient concentration: Make solution only 33% of recommend concentration

c. Adequate concentration: Use solution concentration as recommended.

6. After adding nutrient solution, increments of 20 mL of water is added to each pot until there is dripping from the pots.

7. Students will record the amount of water added, the height of the plant, appearance of the leaves (length, color), and depth of roots.

8. Every 5 to 7 days, water should be added to pots as described in #7 above and observations recorded as in #9 above.

9. The exercise can be ended after about 4 weeks.

*Results* (To be recorded in notebook similar to the tables given below.)

The key results from this exercise will be the length of the shoots on each day. The material below can be put on the blackboard as a guide for the students. In addition, we have learned that some students like to add drawings and/or narratives about the plants. These notes should also be encouraged as part of the notebook.

A graph can be plotted for each of the depth treatments of shoot length vs. dates. The slope of this graph could give insight about the influence of soil depth on growth.

OBJECTIVE: Test growth of maize using different amounts of nutrients.

PROCEDURES:

1. Fill containers with sand.

2. Sow three seeds in each container.

3. Add water in 30 mL increments until dripping.

5. Once seedlings emerge to 2 cm, add 20 mL nutrient solution to each pot at concentrations of 3%, 33%, and 100% of recommended. Afterwards, add water in 20 mL increments until dripping.

6. Record plant heights, leaf length and color, and roots.

7. Every 5 to 7 days afterwards repeat adding water to pots and record observations on plants.

**3% Nutrient Concentration**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DATE** | **Water added (milliliters)**  | **Longest Shoot Length** | **Shoot Observations** | **Root Observations** |
|  |  | 0 | 0 | 0 |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**30% Nutrient Concentration**

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| --- | --- | --- | --- | --- |
| **DATE** | **Water added (milliliters)**  | **Longest Shoot Length** | **Shoot** **Observations** | **Root Observations** |
|  |  | 0 | 0 | 0 |
|  |  |  |  |  |
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**100% Nutrient Concentration**

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| --- | --- | --- | --- | --- |
| **DATE** | **Water added (milliliters)**  | **Longest Shoot Length** | **Shoot Observations** | **Root Observations** |
|  |  | 0 | 0 | 0 |
|  |  |  |  |  |
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