NASA Food Technology Commercial Space Center

Symbioses in Space II: Soybeans in Space by Heidi Kratsch

BACKGROUND

Plant foods constitute most of an astronaut's diet during space travel and must provide all of his/her nutritional needs. Soybeans are a good source of protein and will be used in plant production systems both on the International Space Station and for long-term habitation on the moon and Mars. A variety of cultivation systems have been proposed for growing soybeans in space. Factors that need to be considered in choosing a cultivation system include: limited water and growing space, alteration in light and air quality, weight and biomass restrictions, provision of plant nutrients, and waste processing.

Questions to think about:

- Can beneficial bacteria (i.e. *Bradyrhizobium*) be used to cultivate soybeans in space?
- What can we learn about sustainable cultivation systems from growing plants in space?

LESSON SUMMARY

This activity is appropriate for college-level students with a background in biology, botany, plant physiology, and/or horticulture. It can be used as is, or as a laboratory exercise in conjunction with the lesson, Symbioses in Space I: Plants and Microgravity. If students are to design and set up experiments, the activity will need to be completed in two sessions, at least 4 weeks apart. This activity may be completed in a one-hour class period if the experiments are set up ahead of time.

STUDENT LEARNING OUTCOMES

The student will:

1. Design an experiment that compares different plant cultivation systems for potential use in space (Content).
2. Evaluate the results of their experiment based on previously established criteria (Content).
3. Practice active listening skills in face-to-face interactions (Communication).
4. Encourage participation of all group members (Communication).

ASSESSMENT/ EVALUATION

Evidence of student learning includes:

1. Completion of "Soybeans in Space" worksheet , including Hypothesis, treatments, and appropriate Experimental Controls.

2. Completion of one-page written report of Results and Conclusions.
3. Appropriate verbal and nonverbal responses to group members.
4. Asking for opinions of other group members.

RATIONALE FROM KNOWLEDGE ABOUT LEARNING

1. Students must be exposed to a concept at least eight times before learning occurs. Repetition of a previously taught concept provides an opportunity for deeper learning and greater retention of information.
2. Hands-on activities allow students to transfer what they've learned to new situations.
3. Oral reports and class discussion helps students to process what they've learned and to appreciate the benefits of the collaborative process.
4. Individual accountability for group work assures that each group member is fully invested in the group process.

MATERIALS

Soybean seeds or seedlings (5-10 per group)
4-inch plastic pots
Soil-less potting medium
Soil-containing potting medium
Zeolite soil
1/4 strength Hoagland's solution (+ and – nitrogen)
plastic labels for identification of treatments
permanent markers (one for each group)

INSTRUCTIONS GIVEN TO STUDENTS

1. Instructor provides a brief introduction to, or reminder about, the principles of experimental design.
2. Students work in teams of three or four to design an experiment that tests various plant cultivation systems for growing soybeans in space. Each group completes the "Soybeans in Space" worksheet. Suggested cultivation systems include:
   a. Soil-less potting medium
   b. Soil-containing potting medium
   c. Zeolite soil (Hydroponics or aeroponics could also be used, depending upon available resources.)

   Hint: The nitrogen-fixing bacterium, *Bradyrhizobium*, resides in soil (but not in soil-less medium). This bacterium forms a symbiotic association with soybeans and gives the plant access to atmospheric nitrogen, which is essential for growth. Plants grown in soil-less medium will be dependent upon nitrogen fertilization for growth. Also, this symbiotic association is inhibited by nitrogen in fertilizers. The object of this activity is to determine which combination of planting medium and fertilizer results in the optimal growth of soybean plants.
3. In one month, each group evaluates their culture system by using the

previously established assessment tool (See Symbioses in Space I: Plants and Microgravity). A designated group member reports their results and assessment to the class.

4. Each student is responsible for turning in a one-page written report of his/her group's results and conclusions.

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LEGEND:

—COMMUNICATION MATERIALS
—PROJECT LEARN MATERIALS
—INSTRUCTOR MATERIALS