Plant-A-Plant Mineral Nutrition Laboratory Guide

Task

Transplant maize seedlings in flowerpots and water them with range of fertilizer concentrations. Observe how differences in the availability of mineral nutrients affects plant growth characteristics, including plant height and leaf color. After 16 days of cultivation, harvest plants, make calculations and compare the results between treatments.

Pre-Lab Instructions

1. In your lab groups, begin by considering the following lab questions. In your lab notebook brainstorm your initial ideas possible answers and/or how you might use an experiment to find the answers.
2. Read the lab guide and discuss the experimental design. How does the design test for mineral nutrient requirements of plants?
3. Develop and record an experimental hypothesis in your lab notebook.
4. Based on your discussions and lab procedures, determine the location for your experiment. Record in your lab notebooks why you chose the location and describe how conditions are suitable for individual parts of the experiment.
5. Develop a group schedule for plant cultivation, daily watering responsibilities, making and recording observations, etc.

Lab Questions

How does the amount of available mineral nutrients affect plant growth?
Are mineral nutrients a limiting factor to growth?
How do plants obtain nutrients from the soil?
Why are nutrients necessary for plant growth?
Are some nutrients more important than others for plants to grow and remain healthy?

Prepare and Perform the Experiment

Materials and Tools (*per replicate*)

- ❑ 16 maize seedlings
- ❑ 4 flowerpots (approx. 0.75 liter volume)
- ❑ Growing medium: gardening perlite or sand (4 liters)
- ❑ Fertilizer containing basic nutritients (for example, Kristalon Start or Miracle Gro)
- ❑ Distilled water (4 liters)
- ❑ Measuring cylinder
- ❑ Laboratory scale (accuracy of 0.01 g)
- ❑ 1 beaker or glass jar (volume 100 ml)
- ❑ 4 bottles (volume 1 liter) for fertilizer solution
- ❑ Pencil, permanent marker
- ❑ Scotchtape (cellotape) for labeling
- ❑ *Laboratory Data Sheet* – Mineral Nutrition
- ❑ *Student Laboratory Questions Sheet*

** Note: At least two replicates are recommended for this experiment.

Preparation

1. If necessary, calculate the amount of materials needed for more than 1 replicate.

2. Prepare 1 liter of <u>each</u> fertilizer solution for watering during the experiment.

3. The four different fertilizer solutions are concentrations of: 0 g/l (water), 0.1 g/l, 0.5 g/l, and 1.0 g/l.

4. Mix the fertilizer solutions. For example, for 0.1 g/l weigh out the 0.1 g of powdered fertilizer and dissolve the fertilizer in 1 liter of distilled water. Mix carefully. Repeat for each fertilizer treatment.

5. Pour each fertilizer concentration into a separate bottle and LABEL the fertilizer concentrations on each bottle using a permanent marker. Don't forget to fill and mark one bottle with pure distilled water (0 g/l)! Store bottles in a cool, dark place.

6. Choose a well illuminated place (such as a window sill) in the classroom or laboratory to place pots.

7. Prepare 4 flowerpots (per replicate) by filling them with gardening perlite or sand (to about 2 cm below the edge). When using sand instead of perlite, it is important to wash it with tap water very carefully and dry it a little before putting it into the flowerpots.

Journal Question: Why use perlite or sand instead of potting soil?

8. Label each flowerpot to identify the experimental treatments.

Plant and Observe Seedlings

1. Transplant 4 young seedlings from the germination tray into each flowerpot.

2. Place flowerpots in well lit area.

3. Choose a watering container. The watering quantity will always be 100 ml. Water the plants in each pot <u>every other day</u> with 100 ml of the appropriate fertilizer solution (0.0, 0.1, 0.5, or 1.0 g/l). The first day of watering will be when you transplant the seedlings.

4. Grow plants at room temperature for 13-16 days. Observe plants daily and record any differences between the fertilizer treatments (Table 1 of the Laboratory Data Sheet). Begin observations on day of transplant.

Journal Question: What differences have you noticed after 7 days of cultivation? Do your observations agree with your original hypothesis? Explain.

Harvest the Plants and Evaluate Biomass

Materials and Tools (*per replicate*)

- ❑ Sink / washbasin with tap water
- ❑ Plastic trays (it is possible to re-use the germination trays)
- ❑ Scissors (ideally fine surgical ones or nail scissors) or razor blade
- ❑ Aluminium foil
- ❑ Permanent markers
- ❑ Pencil

- ❑ Laboratory scale (accuracy of 0.01 gram)
- ❑ Absorbent paper (paper towels, filter paper, etc)
- ❑ *Laboratory Data Sheet* - Mineral Nutrition
- ❑ *Data Summary and Analysis Sheet*

  **Note: kiln or drying oven is also necessary

Harvest Procedure

All plants from each flowerpot will be harvested together.

1. Before harvesting plants prepare 3 squares of aluminium foil (approx. 15 x 15 cm each) for each pot: one each for roots, shoots and seeds. Label them with a marker – write the treatment information, such as **roots, 0.5 g/l.**

2. Remove plants from the substrate being careful not to break the roots and place them in a plastic tray filled with tap water. Wash roots completely, do not leave grains of substrate on them (especially important if using sand as substrate). Place plants on absorbent paper (paper towels, filter paper, etc) to dry roots.

3. Use scissors (scalpel, razor blade) to divide the plant into its parts: shoot, roots and seed residues.

4. Place each plant part into its own labeled foil packet– KEEP LABEL VISIBLE.

5. Puncture the foil envelopes/packets several times using the small point of the scissors, a pin or a paperclip to allow evaporating water to escape.

6. Weigh each packet and record the fresh weight on the *Laboratory Data Sheet* (Table 2).

7. Place the packets into kiln or oven at 90 °C and dry them for 8 to 12 hours. It is also possible dry them at lower temperatures but for a longer time (e.g. 60 °C for 2 to 3 days).

Report Results

1. Remove the foil packets from the kiln or oven (carefully as they will be hot) and weigh individually on the scale. Record your packet dry weight value on your worksheet.

2. Follow the instructions on the Laboratory Data Sheet to calculate:
   a. Increase in biomass (in grams of dry weight) (Table 4)
   b. The root-shoot ratio using plant dry weights (Table 5)
   c. Compare results between experimental treatments (Data Summary and Analysis Sheet Table 6)

3. Graph interesting and/or important results.

Conclusions

1. Revise answers to questions posed at the beginning of the experiment in your science notebook or on *Student Laboratory Questions* sheet. Does the experimental outcome provide the answers or at least a clue?

2. Evaluate validity of your hypotheses. Were they supported or rejected? What was your evidence?

3. Did you encounter any issues/difficulties while performing the experiment? What were potential sources of error in the experiment? Are there ways the procedure could be improved?
4. Record any remaining questions about the experiment or its outcomes. How would you design an experiment to test one of these questions?
5. All scientists, once they have completed their investigation, share their findings with peers in their community. Follow the instructions provided by your teacher to share your work.

Plant-A-Plant Student Worksheet – Mineral Nutrition

Student(s): ______________________________ Replicate no. ____________

OBSERVATIONS AND CALCULATIONS (per replicate)

Record data observations and calculations in tables one through five. Shaded cells indicate a calculation is necessary (required equations included below). Tables are designed for a single replicate. Photocopy these tables (pages 5-9) in order to record data for all of your replicates (e.g., pots per treatment).

Plant and Observe Seedlings

During cultivation you may notice differences between experimental treatments. Plant height or changes in shoot leaf color may be some of the notable differences observed. Use a ruler to estimate average seedling height for each flowerpot. Record your observations in Table 1.

Table 1: Observations of Plant Characteristics (dependent variables)

Day of Cultivation	Height Comparison				Shoot Color Changes				Additional Observations or Questions (use backside of data sheet if necessary)
	0	0.1	0.5	1	0	0.1	0.5	1	
1									
2									
3									
4									
5									
6									

Table 1: Observations of Plant Characteristics (dependent variables) Con't									
Journal Question: What differences have you noticed after 6 days of cultivation? Do your observations agree with your original hypothesis? Explain.									
Day	Height Comparison				Shoot Color Changes				Additional Observations or Questions (use backside of data sheet if necessary)
	0	0.1	0.5	1	0	0.1	0.5	1	
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Harvest Plants and Evaluate Biomass

All plants from each flowerpot should be treated as a set and harvested together.

Whole Plant = shoot + root + seed residue.

Mark the foil with replicate number and treatment type.

Table 2: Fresh weight of plant in soil

Treatment (independent variables)	Fresh weight of plant parts in the foil (g)			
	Shoots	Roots	Seed Residue	Whole Plant
0.0				
0.1				
0.5				
1.0				

Don't weight it - calculate it!

Table 3: Dry weight of plant in foil

Treatment (independent variables)	Dry weight of plant parts in the foil (g)			
	Shoots	Roots	Seed Residue	Whole Plant
0.0				
0.1				
0.5				
1.0				

Calculation

Weight whole plant = Weight shoot + Weight root + weight seed residue

Table 4: Increase in biomass (grams dry matter)					
Treatment (independent variables)	Average fresh weight of seed (g) **	Dry weight of seed (g)	Dry weight of seed group (g)	Dry weight of whole plant	Increase in biomass (dry matter in g)
0.0					
0.1					
0.5					
1.0					

Important notes for calculating increase in plant biomass.

Plants consist mainly of water. Water content in leaves is about 60-90%. In contrast, seeds contain only 12% water.

When calculating the increase in maize biomass, you need to know the initial dry weight of the seedlings you have used for planting. However, because it is impossible to measure the dry weight of a seed without damaging it and preventing its ability to grow, we must use the assumption above that seeds contain 12% water. Therefore 88% of the seed's mass is its dry weight.

Remember, you are working with an entire set of plants from a watering system tray; therefore you must multiply the average weight with the appropriate number of plants.

Example: Initial average weight of a seed was 0.420 g, dry matter is 88%.
Average dry weight of seed= 0.88 x 0.420 g = 0.370 g.
You have 10 seeds in one experimental system, thus:
The average dry weight of the seeds = 10 x 0.370 g = 3.7 g.
Increase in biomass = Dry weight of harvested plants - 3.7 g.

Calculations:

** = from germination datasheet

Dry weight of seed = Average fresh weight of seed** x 0.88

Dry weight of seed group = Dry weight of 1 seed x Number of plants in the treatment (tray)

Increase in biomass = Dry weight of whole plants – Dry weight of seed group

Table 5: Weight Ratio- root:shoot (dependent variable)			
Treatment (independent variables)	Dry Weight of Roots (g)	Dry Weight of Shoots (g)	Ratio root:shoot
0.0			
0.1			
0.5			
1.0			

The root:shoot ratio is one measure to help you assess the overall health of plants. The root:shoot ratio measures the allocation of carbon in the form of photosynthate to the roots (below ground tissue) and shoots (above ground tissue). Environmental stimuli (e.g., light, CO_2) may influence carbon.

Calculations:

Root:shoot ratio = Dry weight of roots / Dry weight of shoot

Plant-a-Plant Student Laboratory Questions: **Answer the questions and identify the sources for your ideas (D,B,S).**

	Pre-Lab: Existing Knowledge	Can this question be answered by this experiment? (Y/N)	**Post-Lab: Knowledge Gained**	To what extent was the question answered? (All, In, part, Not at all)
How does the amount of mineral nutrients affect plant growth?				
Are mineral nutrients a limiting factor to growth?				
How do plants obtain nutrients from the soil?				
Why are nutrients necessary for plant growth?				
Are some nutrients more important than others for plants to grow and remain healthy?				

Identifying Sources for Ideas (adapted from GLOBE Earth Systems - LC1)

For each laboratory question identify what kind of source you used for the idea. Record the designation by writing the letter next to your idea and circling it for distinction.

D B S

D – Your answer is based on **data**. Use “D” to designate an idea for which you have collected or seen supporting data. Data could have been collected by your class, another GLOBE school, or others.

B – Your source is **background information**. Use “B” to designate an idea that you have recalled from a previous reading or experience in another course, at home, or elsewhere, and that you could actually find and bring to class. There may be data somewhere to substantiate this information, but you have either not seen it or do not have access to it.

S – Your source is **speculation**. Use “S” to designate an idea based on scientifically informed speculation. This is your opinion founded on what you have learned over time, but you can not point to a particular source of data or other information to support it. (Creative speculation – when based on authoritative background information and data – is one of the keys to excellent scientific work.)