Plant-A-Plant Water Laboratory Guide

Task

Prepare conditions for growing maize seedlings with different amounts of water. Plant seedlings into plastic bottles, set up a constant water resource and observe how much water uptake occurs. Develop a control system to account for changes in water level not caused by plant uptake. After the experiment is complete you will compare the change in plant biomass of the different water 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 water availability to 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

Is water a limiting factor to plant growth?

Sub-Questions

Are plants able to grow without water?
Why do plants need water for growth?
How much water does a plant contain?
How does the amount of water affect plant growth?

Prepare and Perform the Experiment

Materials and Tools (*per replicate*)

- ❑ 16 maize seedlings
- ❑ 3 2-liter clear plastic bottles
- ❑ Gardening perlite or sand (0.5 liter)
- ❑ Fertilizer containing basic nutrients (e.g. Kristalon Start or Miracle Gro)
- ❑ Distilled water (1 liter)
- ❑ Measuring cylinder
- ❑ Laboratory scale (accuracy of 0.01 g)
- ❑ Pencil, permanent marker
- ❑ Scotchtape (cellotape) for labeling
- ❑ *Laboratory Data Sheet* – Water

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

Preparation

1. Mix the fertilizer solution
   a. Place 1 liter of distilled water in a 1 liter (or larger) container with cap.
   b. Weigh a small piece of paper (to be used to transport fertilizer).
   c. Weigh 0.2 g of powered fertilizer onto piece of paper (remember to subtract the weight of the paper to ensure 0.2 g of fertilizer).
   d. Add fertilizer to distilled water.
   e. Mix fertilizer into distilled water carefully.
   f. Note: The solution can be made in advance and stored closed for several days until needed. Before using gently shake the bottle to re-mix solution.

2. Wash the bottles thoroughly - do not use any cleansers, since these could influence the growth of plants. Allow the bottles to air-dry. Be sure to choose transparent bottles, since colored plastic will affect the growth of the plants.

3. Cut the top half off the bottles using scissors or a razor blade. Be careful as you will need both halves: one for planting and one for the water reservoir (See appendix for visual example). Remove and discard the bottle cap.

4. Place the fertilizer solution into the bottom half of the 3 bottles described below to create the water reservoir:

Treatment	Volume (ml)
A - Control without plants	50
B - Plants - less water	150
C - Plants - more water	300

5. Carefully mark each bottle with the correct treatment label (A, B or C) according to the table in Step 1 (above).

6. In a separate dish or tray wet the growing medium (perlite or sand). This will *prevent it from extracting* too much water from your water reservoir (aka the bottom of the bottle) before beginning your experiment.

7. Divide the growing medium into three equal portions and place it in the inverted top half of each bottle (See appendix for visual example).

Plant and Observe Seedlings

1. Set the 150 ml watering system marked **A** (see table in Step 1) aside (with only sand/perlite - no plants) as a control to observe loss of solution by evaporation.

2. Plant 8 seedlings into the 150 ml watering system marked **B**. Plant 8 seedlings into the 300 ml watering system marked **C**.

3. Mark the height of the fertilizer solution in the bottle water reservoir with a marker. Grow the plants for 11 days, and observe and record both plant growth and decrease of solution in the watering system.

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
- ❑ Measuring Cylinder
- ❑ Permanent markers
- ❑ Pencil
- ❑ Laboratory scale (accuracy of 0.01 gram)
- ❑ Absorbent paper (paper towels, filter paper, etc)
- ❑ *Laboratory Data Sheet - Water (Harvest)*
- ❑ *Data Summary and Analysis Sheet*

**Note: kiln or drying oven is also necessary

Harvest Procedure

1. Before harvesting plants prepare 4 squares of aluminium foil (approx. 15 x 15 cm each) for each tray: one each for roots, shoots, seeds, and soil. Label them with a marker – write the treatment information, such as ***roots, 150 ml*** and the replicate number.

2. Remove the bottle tops from the water reservoir. Measure the amount of water left in the reservoir, and record the value on Table 2A.

3. Harvest all plants from one bottle at the same time.

4. 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.

5. Use scissors to divide plant into its parts: root, shoots and seed residue. Group like parts from the same bottle together place on a single foil square and close the square, creating a small foil envelope or packet. ***IMPORTANT:*** keep the label visible. As an added precaution, it is advisable to write all information that was written on foil squares also on your Data Sheet in the event that some piece of information is lost. Feel free to use notations such as *B-root, B-shoot or B-seed* (meaning Watering system B roots, shoots or seeds).

6. Place the remaining soil along with the in a single foil square and creating a small foil envelope or packet.

7. Weigh the ALL foil packets and record the fresh weight on **Table 2B**.

8. 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.

9. 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. Calculate the Soil Water Content for each treatment (**Table 2C**)
2. Follow the instructions on the *Laboratory Data Sheet* to calculate:
    c. Increase in biomass (in grams of dry weight) (Table 3)
    d. The root-shoot ratio using plant dry weights (Table 4)
    e. Water content of plants and soil (Table 5)
    f. 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?

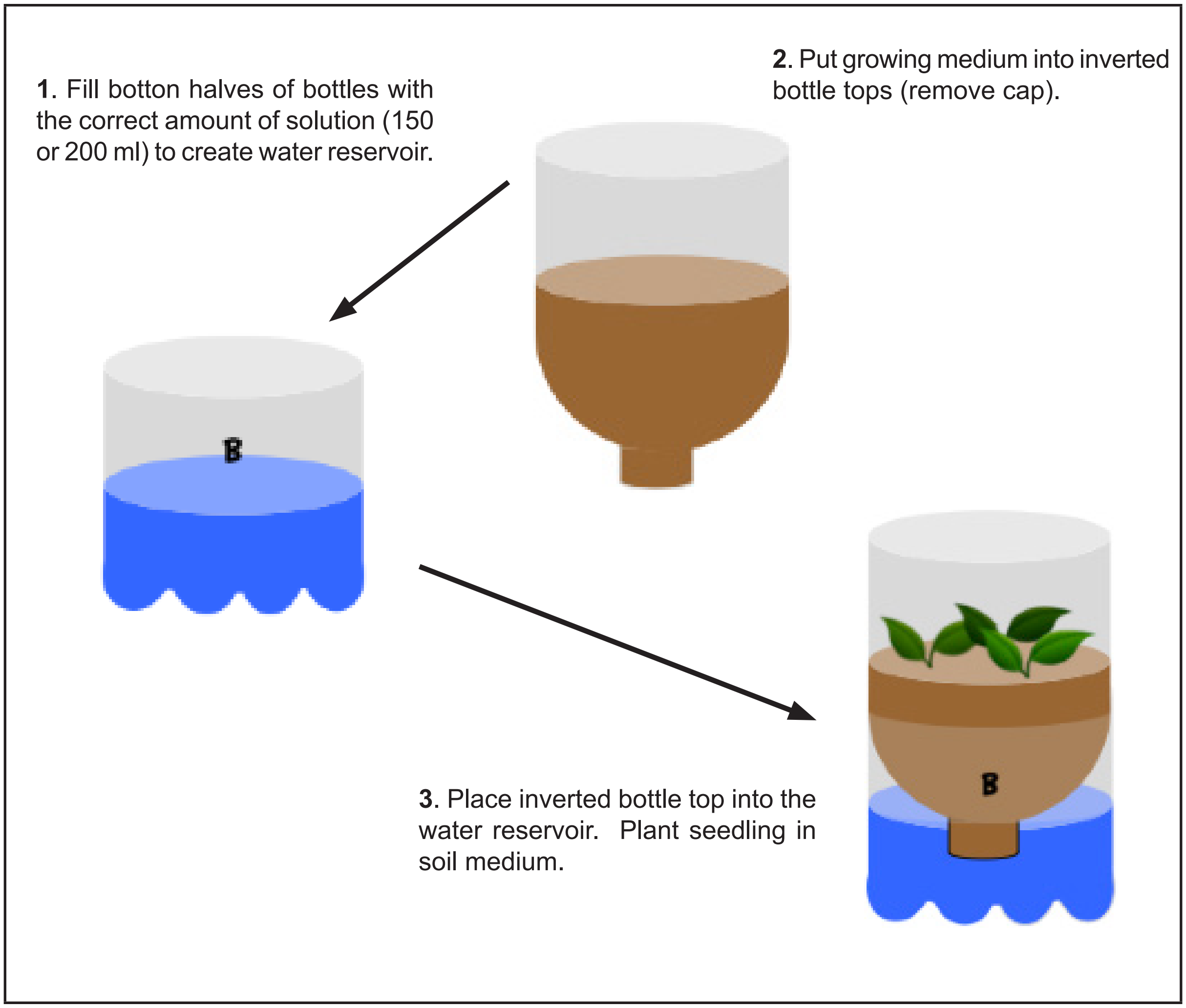
2. Evaluate validity of your hypotheses. Were they supported or rejected? What was your evidence?

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.

Appendix – Setting up the watering system



Materials required: 3 2-liter bottles, cut in half.

Plant-A-Plant Student Worksheet – Water

Student(s): ______________________________ Replicate no. ____________

OBSERVATIONS AND CALCULATIONS (per replicate)

Record data observations and calculations in tables one through six. Shaded cells indicate a calculation is necessary (required equations included below). Tables are designed for a single replicate. Photocopy these tables (pages 6-11) in order to record data for <u>all</u> 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)
	150 ml water	300 ml water	150 ml water	300 ml water	
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)
	150 ml water	300 ml water	150 ml water	300 ml water	
7					
8					
9					
10					
11					
12					

Harvest Plants and Evaluate Biomass

All plants from each bottle should be treated as a set and harvested together (as a replicate).

Whole Plant = shoot + root + seed residue.

Mark the foil with replicate number and treatment type.

Table 2A: Water Reservoir	
Treatment (independent variables)	Remaining Water (ml)
150 ml water - no plants	
300 ml water - with plants	
300 ml water - with plants	

Table 2B: Fresh weight of whole plant, parts, and soil					
Treatment (independent variables)	Fresh weight of plants in the foil (g)				
	Shoots	Roots	Seed Residue	Soil	Whole Plant
150 ml water					
300 ml water					

Don't weight it - calculate it!

Table 2C: Dry weight of whole plant, parts, and soil (dependent variable)						
Treatment (independent variables)	Dry weight of plant parts in the foil (g)					
	Shoots	Roots	Seed Residue	Soil	Whole Plant	Soil Water Content
150 ml water						
300 ml water						

Calculations:

Weight whole plant = Weight shoot + Weight root + weight seed residue
Soil Water Content = (Soil Fresh Weight - Soil Dry Weight) / Soil Dry Weight

Table 3: Increase in biomass (dependent variable)					
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)
150 ml water					
300 ml water					

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 4: Water Content (dependent variable)				
Whole Plant				
Treatment (independent variables)	Fresh Weight (g)	Dry Weight (g)	Water (%)	Dry Matter (%)
150 ml water				
300 ml water				
Roots				
Treatment (independent variables)	Fresh Weight (g)	Dry Weight (g)	Water (%)	Dry Matter (%)
150 ml water				
100 ml water				
Shoots				
Treatment (independent variables)	Fresh Weight (g)	Dry Weight (g)	Water (%)	Dry Matter (%)
150 ml water				
300 ml water				
Seed Residue				
Treatment (independent variables)	Fresh Weight (g)	Dry Weight (g)	Water (%)	Dry Matter (%)
150 ml water				
300 ml water				
Soil				
Treatment (independent variables)	Fresh Weight (g)	Dry Weight (g)	Water (%)	Dry Matter (%)
150 ml water				
300 ml water				

Calculations

% Water = (dry weight of a whole plant / fresh weight of a whole plant) x 100
% Dry matter = (1-(dry weight of a whole plant / fresh weight of a whole plant)) x 100

Table 5: Weight Ratio- root:shoot (dependent variable)			
Treatment (independent variables)	Dry weight of roots (g)	Dry weight of shoots (g)	Ratio root:shoot
150 ml water			
300 ml water			

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 available water affect plant growth?				
Is water a limiting factor to growth?				
Why do plants need water for growth?				
How much water does a plant contain?				
Are plants able to grow without water?				

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.)