Plant-A-Plant Temperature Laboratory Guide

Task

Prepare conditions for the cultivation of maize in a closed system (plastic bottle). You will observe the influence of different temperatures on growth. You will achieve different temperatures by shading a third of the plastic bottle. Compare the increase in biomass between the different modifications.

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 the effect of temperature on 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 temperature a limiting factor to plant growth?

Sub-Questions

Does the outside temperature influence accumulation of carbon inside the plant?
What happens to the plants when the temperature is too low/ too high?
How does temperature affect plant growth?

Prepare and Perform the Experiment

Materials

- ❑ 15 Germinated maize seedlings
- ❑ Three 2-litre plastic bottles
- ❑ Fertilizer solution (0.2g/l)
- ❑ Glass rods
- ❑ Measuring cylinder
- ❑ Aluminium foil
- ❑ Thermometers
- ❑ Scissors
- ❑ A paintbrush
- ❑ Lab scales (accurate to 0.01 g)
- ❑ Tubes of paint (black and white)
- ❑ Tissue paper
- ❑ Drying oven, regular oven or a microwave oven
- ❑ Alcohol-based permanent marker
- ❑ Black paper and white paper
- ❑ Sticky tap

** 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. Wash the bottles thouroughly - 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 1/3 off the bottles using scissors or a razor blade. Be careful as you will need to tape the top back to seal the bottle on after you plant the seedlings.
4. Paint (or use paper to cover) the upper third of two of the bottles with paint – one white, the other black. The third bottle will remain transparent as a control.
5. Mix a 0.2 g/l fertilizer solution. Weigh 0.2 g of fertilizer and dissolve into one liter of distilled water. Pour fertilizer solution into a labeled bottle. The fertilizer solution will be the growth medium for the Temperature experiment.
6. Add 30 ml of fertilizer solution to each experimental bottle.

Plant and Observe Seedlings

1. Transplant 4-5 germinated seedlings to each bottle. It is important that only the roots are submerged. Use the measuring rod to compare the height of your plants.
2. Close the bottles carefully and don´t open them during the experiment.
3. Attach thermometers with string or thread around the neck of the bottle and lower them inside.
4. Screw the cap back on and make sure you can read the temperature from the outside.
5. Place the bottle in direct sunlight and grow plants for 10-14 days.
6. Read the temperature in each bottle at the same time every day and record it the *Laboratory Data Sheet* Table 1.

Harvest the Plants and Evaluate Biomass

Materials

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

**Note: kiln or drying oven is also necessary

Harvest Procedure

All plants from each flowerpot will be harvested together.

1. Before harvesting plants prepare 2 squares of aluminium foil (approx. 15 x 15 cm each) for each bottle: one for roots and shoots. Label them with a marker – write the treatment information, such as **roots, black paint** and number of replicate.
2. Remove the tape, the top of the bottle and then the plants. Plant roots may be interlaced; therefore harvest and weigh all the plants from each bottle together (1 group of roots and 1 group of shoots).
3. Use scissors to cut the shoots from the roots. Place the roots in a plastic tray containing tap water to prevent drying.
4. Package shoots into the labeled foil squares – KEEP LABELS VISIBLE. Repeat the process for roots.
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 all foil packets and record the fresh weight on 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 and weigh individually on the scale. Record your packet dry weight value on your *Laboratory Data Sheet* (Table 3).
2. Follow instructions in the harvest section of the student worksheet 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 in the *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 – Temperature

Students: _____ 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 1-4) in order to record data for all of your replicates (e.g., bottles per treatment).

Plant and Observe Seedlings

During cultivation, besides measuring and recording the temperature, 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	Height Comparison			Shoot Color Changes			Bottle Temperature		
	Black	White	Control	Black	White	Control	Black	White	Control
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			Bottle Temperature		
	Black	White	Control	Black	White	Control	Black	White	Control
7									
8									
9									
10									
11									
12									
13									
14									

Harvest Plants and Evaluate Biomass

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

Whole Plant = shoot + root. Seed is not included.

Mark the foil with replicate number and treatment type.

Table 2: Fresh weight of whole plants and parts

Treatment (independent variables)	Fresh weight in foil (g)		
	Shoots	Roots	Whole Plant
Black Paint			
White Paint			
Control			

Table 3: Dry weight of whole plants and parts (dependent variable)

Treatment (independent variables)	Dry weight of plant parts in foil (g)		
	Shoots	Roots	Whole Plant
Black Paint			
White Paint			
Control			

Don't weight it - calculate it!

Calculations

Weight whole plant = Weight shoot + Weight root

Table 4: 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)
Black Paint					
White Paint					
Control					

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
Black Paint			
White Paint			
Control			

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 temperature affect plant growth?				
Is temperature a limiting factor to growth?				
Does the outside temperature influence accumulation of carbon inside the plant?				
What happens to the plants when the temperature is too low/ too high?				

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 – 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.)