Effect of Acid Rain on Plant Growth

Introduction

This is a companion lab to the "Effect of Plant Nutrients in Soil and Soil pH on Plant Growth" lab.

Acid rain is a term commonly used to refer to all types of precipitation--rain, snow, sleet, hail, fog--that is acidic in nature. A more encompassing term is acid deposition. Rain is naturally somewhat acidic, with an average pH of 5.6-5.7. Precipitation is considered "acidic" if it has a pH lower than the average pH of rainwater.

Rain is naturally acidic because carbon dioxide, found normally in the earth's atmosphere, reacts with water to form carbonic acid. While rainwater has an average pH of 5.6-5.7, actual pH readings will vary from place to place depending upon the type and amount of other gases present in the air, such as sulfur dioxide and nitrogen oxides.

Acid rain has many negative impacts. It kills aquatic life, trees, crops and other vegetation, damages buildings and monuments, corrodes copper and lead piping, damages man-made things such as automobiles, reduces soil fertility and can cause toxic metals to leach into underground drinking water sources.

The term pH refers to the free hydrogen ions in water and is measured on a scale from 0 to 14. Seven is considered neutral, measurements below seven are acidic, and measurements above seven are basic or alkaline. Every whole number value on the pH scale represents a tenfold increase over the previous whole number. Thus, pH 4 is 10 times more acidic than pH 5 and 100 times more so than pH 6. Similarly, pH 9 is 1O times more basic than pH 8 and 100 times more basic than pH 7.

Two air pollutants, sulfur dioxide (SO_2) and nitrogen oxides (NOx), are thought to be contributing to the acid rain problem. These pollutants are emitted primarily from utility and smelter "smokestacks" and automobile, truck and bus exhausts, but they also come from burning wood.

When these pollutants reach the atmosphere they combine with gaseous water in clouds and create acids--sulfuric acid and nitric acid. Then, rain and snow wash these acids from the air.

Acid rain can adversely affect plants in many ways including: 1) damaging leaves directly by damaging the protective waxy coating which allows acids to

diffuse into them, interrupting the evaporation of water and gas exchange; 2) leaching essential plant nutrients from soils, resulting in reduced plant productivity; 3) releasing aluminum ions attached to insoluble soil particles which then hinder the uptake and use of nutrients and water by the plant; 4) releasing ions of metals such as cadmium, lead and mercury that are toxic to plants; and 5) generally weakening plants such that they become more susceptible to damage from insects, disease, drought, or environmental extremes.

In this lab, the growth of radish plants watered with simulated acid rain will be compared to the growth of radish plants watered with tap water.

The radish plants potted in potting soil for the "Effects of Plant Nutrients in Soil and Soil pH on Plant Growth" lab will serve as the controls for this lab. We will plant radish seeds in potting soil and allow them to grow for 5 weeks while watering them with simulated acid rain (except for the first week when they will be watered with tap water to ensure that they germinate, and the second week when they will be watered with a simulated acid rain/tap water mixture). Each week the plants will also be observed and measured. In week 6 of the exercise (5th week of growing), the mass of the plants will be determined. The growth data for the plants watered with simulated acid rain will then be compared to the plant growth data for the plants watered with tap water in the "Effects of Plant Nutrients in Soil and Soil pH on Plant Growth" lab.

Hypothesis

Plants watered with tap water will exhibit better growth, as evidenced by mean plant height and mean above soil plant mass, than plants watered acid simulated acid rain.

Materials

- Nutritionally-enhanced commercial potting soil
- 4" round plastic plant pots
- Trays
- Permanent markers
- Radish seeds
- Tap water
- Simulated acid rain
- 50ml plastic beaker

Procedure

Week 1 - Planting Seeds

1. Work in groups by lab table.
2. Obtain 3 4" plastic plant pots
    a. place a strip of masking tape on each pot

   b. using a permanent marker, label the masking tape of each pot with the following information
      1) lab table number
      2) "acid" pot number (acid #1, acid #2, acid #3) (NOTE: It is very important that you write "acid" so as not to confuse these pots with the control pots)
      3) lab section #
3. Fill each pot with the appropriate soil until the pot is ¾ full
4. Plant **five** radish seeds in each pot, approximately 15mm deep
5. Water each pot with 50ml of tap water
6. Place pots on plastic trays and place trays in greenhouse as directed by instructor

Weeks 2

1. Water each pot with 15ml of tap water AND 15ml of simulated acid rain.
2. Observe the pots and determine for each the number of plants that have either germinated or have become a seedling and record this number in Table 1. Eventually, this number will reflect the number of plants as all seeds will have germinated.
3. Observe the pots and record for each a qualitative description of plant color in Table 1. (Examples: healthy dark green, pale green, yellowish, yellowish with spots).
4. Observe the pots and determine for each the average plant height (in mm) and record in Table 1. To do this, measure the tallest part of each plant (there should be no more than 5 separate plants if you followed the planting instructions carefully), add those 5 values and then divide by 5.

Weeks 3-5

5. Water each pot with 30ml of simulated acid rain ONLY
6. Observe the pots and determine for each the number of plants that have either germinated or have become a seedling and record this number in Table 1. Eventually, this number will reflect the number of plants as all seeds will have germinated.
7. Observe the pots and record for each a qualitative description of plant color in Table 1. (Examples: healthy dark green, pale green, yellowish, yellowish with spots).
8. Observe the pots and determine for each the average plant height (in mm) and record

in Table 1. To do this, measure the tallest part of each plant (there should be no more than 5 separate plants if you followed the planting instructions carefully), add those 5 values and then divide by 5.

Weeks 6

1. Observe the pots and determine for each the number of plants record this number in Table 1.
2. Observe the pots and record for each a qualitative description of plant color in Table 1.
3. Observe the pots and determine for each the average plant height (in mm) and record in Table 1.
4. Determine and record in Table 1 the mass of plants above the soil line for each pot by using a razor blade to cut the plant stems at soil level. This means you must weigh all the plants (above the soil line) for a given pot at one time.
5. Determine the mean above soil plant mass (g) for your group and record in Table 1. To do this, add the three mass values you obtained in step 4 above and then divide by three.
6. Record in Table 2 and on the transparency the mean above soil plant mass (g) for your group (from your Table 1). Also record in Table 2 the mean above soil plant mass (g) for all other groups (from the transparency).
7. Record in Table 3 and on the transparency the mean plant height (mm) for your group (from your Table 1). Also record in Table 3 the mean plant height (mm) for all other groups (from the transparency).
8. Discard the plant material after weighing it. There should be a labeled container in the greenhouse for waste organic material.
9. Return the soil in each pot to the appropriate container based on its type.
10. Remove the masking tape from each pot and wash the pot.
11. Clean up your work area.

Data Analysis

1. Complete the "top water" columns of Table 2 and Table 3 in this exercise by transferring to them the data from the "potting" soil column of Table 2 and Table 3 in the "Effect of Plant Nutrients in Soil and Soil pH on Plant Growth" lab exercise. Also, compute the mean of the means for both columns in Table 2 and Table 3.

2. Complete Figure 1 by preparing a line graph illustrating your group's mean plant height (mm) for each week for plants watered with tap water versus plants watered with simulated acid rain. This graph should have two lines. The data for the line for plants watered with simulated acid rain will come from Table 1 in this lab exercise (the mean plant height (mm) for each week). The data for the line for plants watered with tap water will come from Table 1 of the "Effect of Plant Nutrients in Soil and Soil pH on Plant Growth" lab exercise (the mean plant height (mm) for "potting" soil plants for each week).
3. Complete Figure 2 by preparing a bar graph illustrating the class-wide mean plant above soil mass (g) for plants watered with simulated acid rain versus plants watered with tap water. You will be using the data from Table 2 in this exercise.

3. Complete Figure 3 by preparing a bar graph illustrating the class-wide mean plant height (mm) for plants watered with simulated acid rain versus plants watered with tap water. You will be using data from Table 3 in this exercise.

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Student Name: _____ Lab Date: _____

Lab Instructor: _____ Lab Section: _____

Table 1: Weekly germination, height and color data for radish plants watered with simulated acid rain by replicate for individual lab group.

	Watered with:	Simulated Acid Rain			
	Soil:	Potting Soil			
Week:	Pot #:	1	2	3	Mean
2	# germinated/# plants				
	Height (in mm)				
	Color				
3	# germinated/# plants				
	Height (in mm)				
	Color				
4	# germinated/# plants				
	Height (in mm)				
	Color				
5	# germinated/# plants				
	Height (in mm)				
	Color				
6	# germinated/# plants				
	Height (in mm)				
	Color				
	Mass (above soil, in g)				

- Continued -

Table 2. Mean plant above soil mass (g) for radish plants watered with simulated acid rain versus tap water by lab group.

	Mean plant above soil mass (g)	
Lab Table	Simulated Acid Rain	Tap Water
1		
2		
3		
4		
5		
6		
Mean		

Table 3. Mean plant height (mm) for radish plants watered with simulated acid rain versus tap water by lab group.

	Mean plant height (mm)	
Lab Table	Simulated Acid Rain	Tap Water
1		
2		
3		
4		
5		
6		
Mean		

- Continued -

Figure 1. Mean plant height (mm) each week for plants watered with simulated acid rain versus plants watered with tap water for individual lab group.

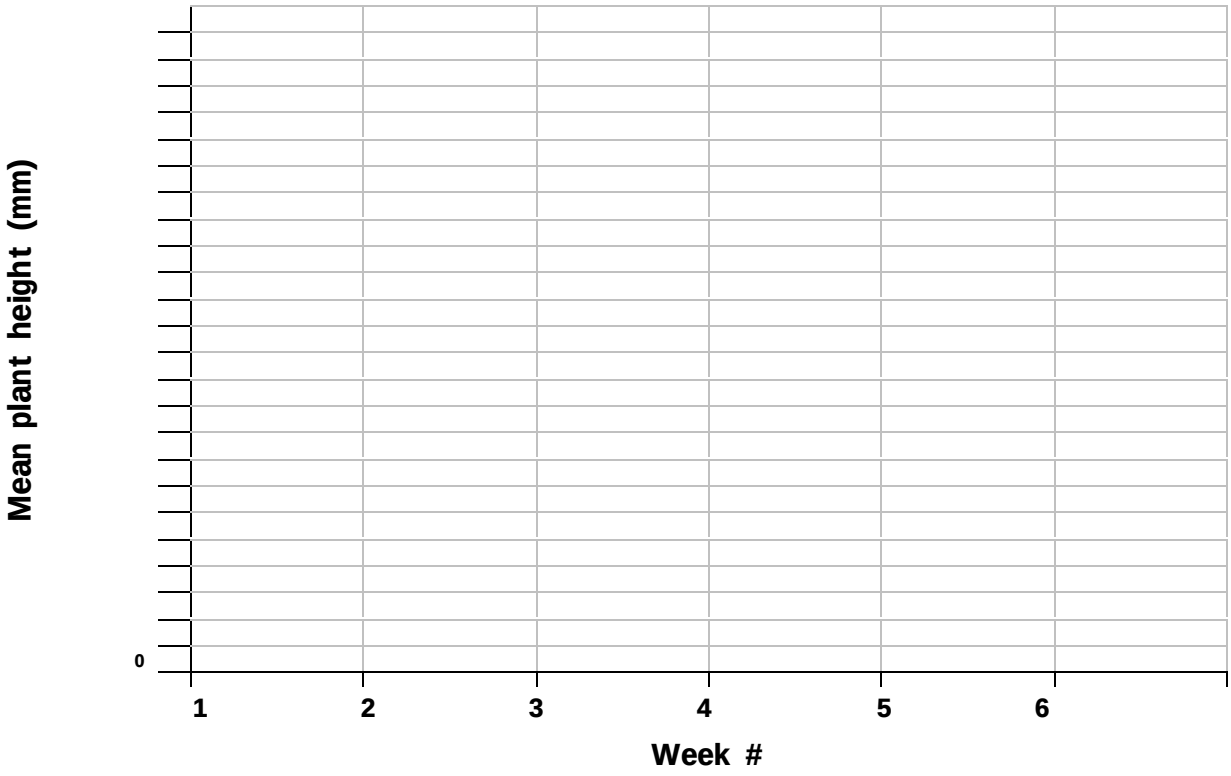


Figure 2. Class-wide mean plant above soil mass (g) for plants watered with simulated acid rain versus plants watered with tap water.

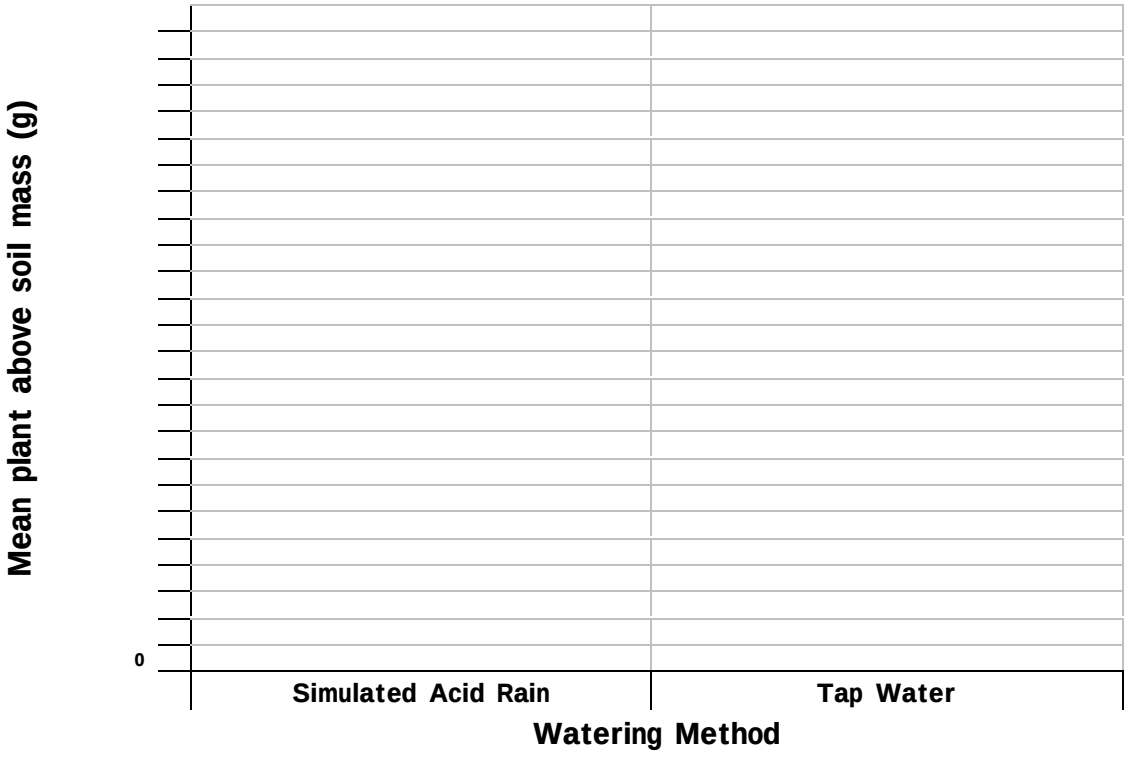
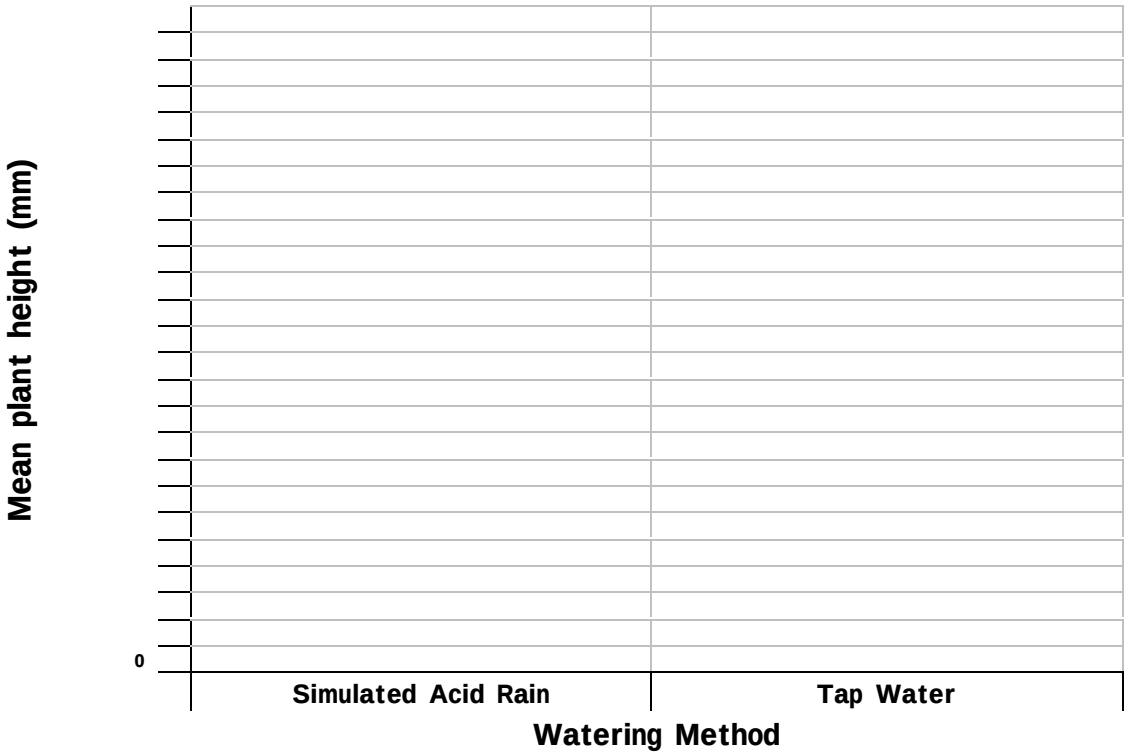


Figure 3. Class-wide mean plant height (mm) for plants watered with simulated acid rain versus plants watered with tap water.



Conclusions (Questions): *For full credit, these questions should be answered thoroughly, in complete sentences, in legible handwriting.*

1. Were there any differences between mean plant above soil mass by lab group? Were there any differences between mean plant height by lab group? Is so, speculate on possible reasons for these differences.

2. Compare the plant growth, as evidenced by mean plant height and mean plant above soil mass, for plants watered with tap water versus plants watered with simulated acid rain. Under which watering conditions did the plants grow best? Is this consistent with your expectations?