Effects of Acid Rain on Radish Seed Germination

Topic

Acid rain can have a detrimental effect on seed germination.

Introduction

The term pH, which stands for "potential of hydrogen," indicates the acidity or alkalinity of a solution. The pH scale ranges from 0 to 14. The central point, 7, represents a neutral solution, while a solution with a pH less than 7 is an acid, and a solution with a pH greater than 7 is a base. On the pH scale, 1 unit represents a 10-fold change in pH, so a solution with a pH of 3 is 10 times more acidic than a solution with a pH of 4. In the same way, a pH of 10 is 10 times 10, or 100 times, more basic than a pH of 8 (Figure 1).

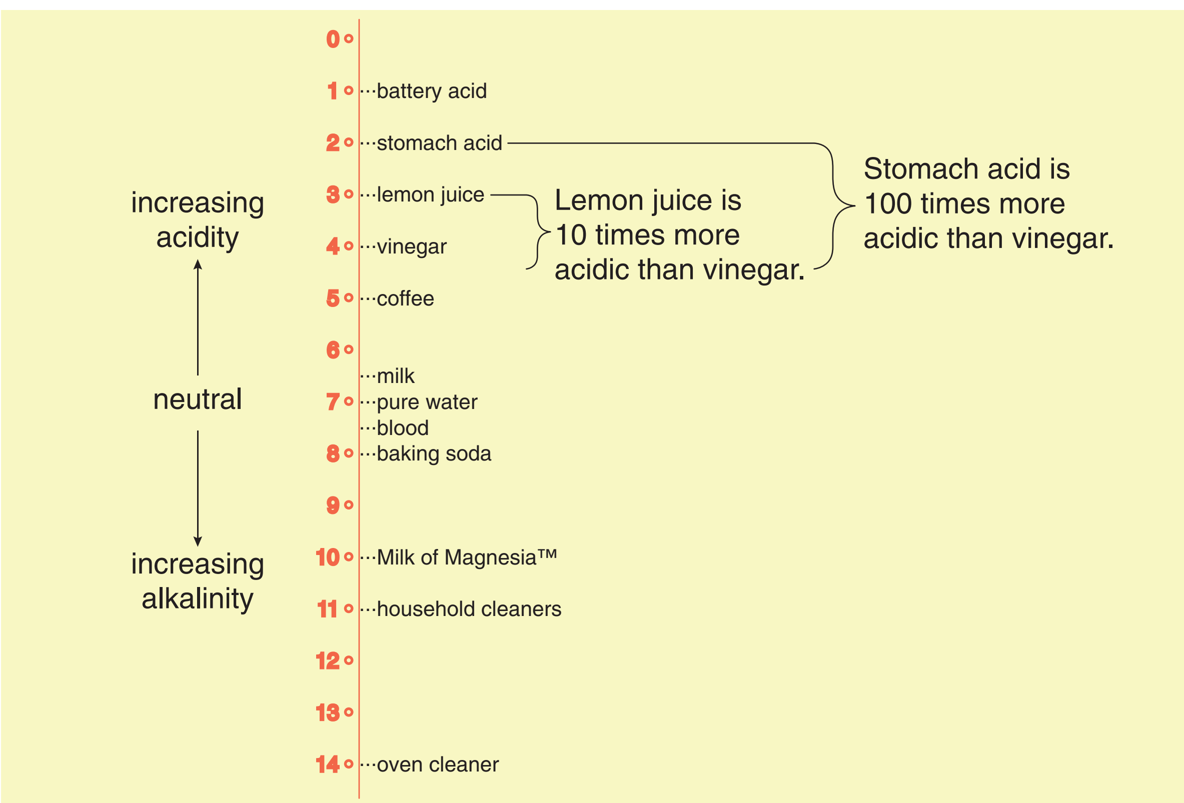

Figure 1

Rain falling from the sky is not completely neutral, as some might believe. Instead, normal rain is slightly acidic. The acidity in normal rain is due to the presence of carbon dioxide in the atmosphere. When carbon dioxide dissolves in water, a weak carbonic acid solution forms. As a general rule normal rainfall has a pH that ranges from 5.6 to 6.

If the pH of rain drops below 5.6, it is considered acid rain. Acid rain forms when air pollutants like sulfur dioxide and nitrogen oxide, two gases that are produced by the burning of fossil fuels, dissolve in rainwater. Acidic rain can have detrimental effects on plant and animal life, as well as on the condition of buildings, statues, and cars.

Fields of food crops can be affected by the acidity of rain. In many types of plants, the percentage of seeds that germinate is reduced under acidic conditions. Seed germination, a critical step in crop production, is the process in which the seed coat softens and stored starch inside the seed is changed to sugar that the developing embryo can use to fuel its growth.

Imagine a hypothetical community called Hillgroth, where farms have superb reputations as high-yield radish producers. However, farmers have experienced a significant drop in both radish seed germination and radish crop yields over the last 5 years. Your lab team has been employed by the Hillgroth county extension office to find out why. Specifically, the county extension service wants to know whether or not these crop problems are related to acid rain that may be resulting from an increase in industry and highway traffic. The county extension service knows that farms in less-developed parts of the state, such as the town of Bootlap, have not suffered the same kinds of problems as those near busy roads and large, coal-burning industries.

In this lab, you will follow a lab procedure and use your results to decide whether or not acid rain reduces the percentage of radish seeds that germinate.

Time Required

50 to 60 minutes on day 1
10 minutes on days 3, 5, 7
30 minutes on day 9

Materials

- goggles
- lab aprons
- 50-milliliter (ml) beaker
- glass slide
- 3 medicine droppers
- 30 radish seeds
- 4 petri dishes and lids
- shoe box with lid
- 1 roll of paper towels
- scissors
- test tube of mold inhibitor
- test tube of solution A
- test tube of solution B
- test tube of solution C
- test tube rack
- 3 pieces of pH paper
- pH color chart
- metric ruler
- masking tape
- pen
- science notebook

Safety Note **Please review and follow the safety guidelines. The mold inhibitor can give off strong fumes, so avoid inhaling its vapors.**

Procedure

Day 1

1. Place three pieces of pH paper side by side on the glass slide. Label the piece of paper on the left side of the slide as 1, the middle piece as 2, and last piece as 3.
2. Solution A represents rain that was collected in the community of Hillgroth, solution B is rain from Bootlap, and solution C is the control, distilled water. With three different medicine droppers, add a drop of solution A to paper 1, add a drop of solution B to paper 2, and finally add a drop of solution C to paper 3. Allow these to dry, then match the colors on each piece of paper to the numbers on the pH color chart. Record these numbers on Data Table 1.

Data Table 1: pH of samples A, B, and C

pH of solution A	pH of solution B	pH of solution C

3. Place 30 radish seeds in the bottom of the 50-ml beaker, and pour mold inhibitor solution on top of the seeds until they are completely submerged. Allow the seeds to soak for 10 minutes. Afterwards, rinse the seeds with tap water, then pat them dry with paper towels.
4. Place the bottom portion of a petri dish on a paper towel and trace around the dish with a pencil. Use the scissors to cut out this circle. Repeat this procedure 17 more times so that you have six paper towel circles for each petri dish (Figure 2).

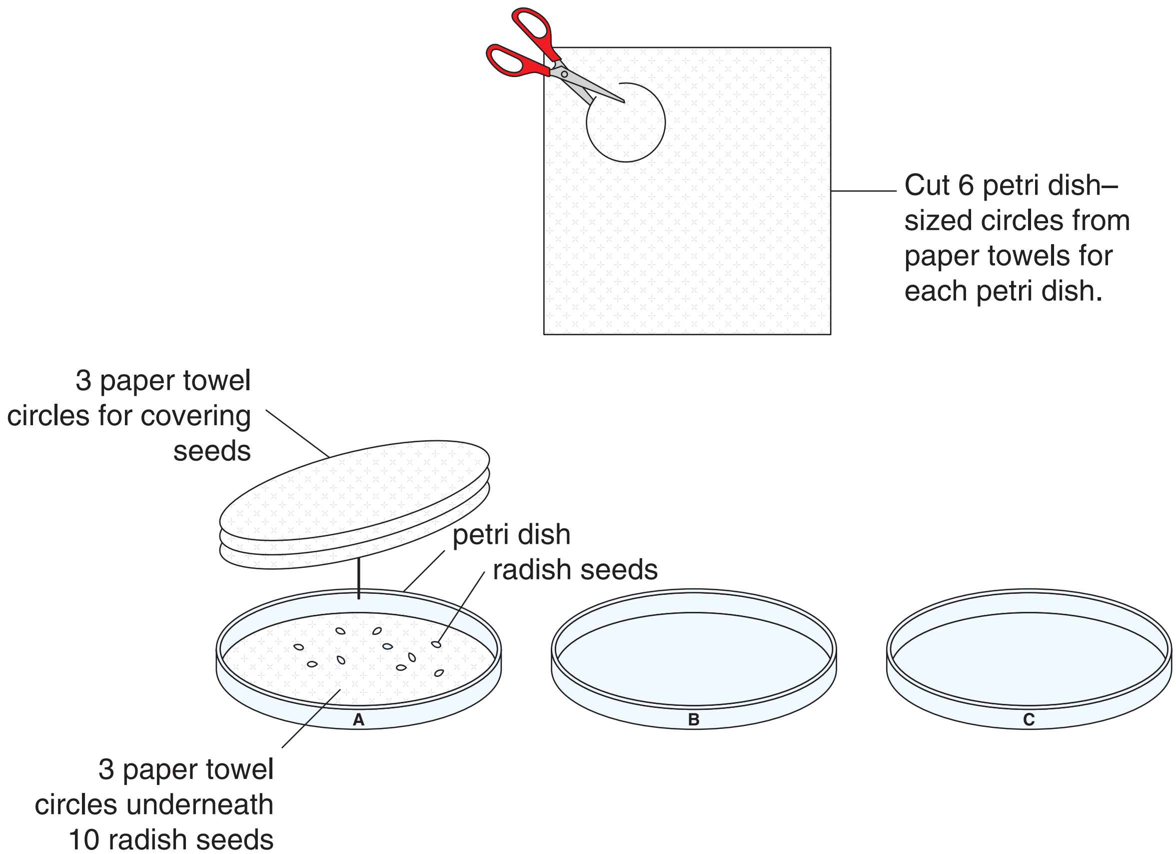

Figure 2

5. Use masking tape and a pen to label the lids of the petri dishes as A, B, and C.
6. Place three paper towel circles in the bottom of dish A. With a medicine dropper, add a few drops of solution from container A to the paper towel circles in dish A. Continue to add drops until the paper towels are damp, but not soggy. If any liquid pools in the dish, pour it out
7. Evenly space 10 radish seeds on the damp paper towels of dish A (Figure 2). Place three more circles of paper towel in the lid of dish A. Wet these with liquid from container A, just as you wet the ones in the bottom of the dish. Once they are damp with no liquid standing, place these paper towel circles on top of the radish seeds so that all seeds are completely covered. Put the lid on dish A and place it in the shoe box.
8. Repeat steps 4 through 7 for petri dish B, but this time use liquid

from container B. Place this petri dish in the shoe box.

9. Repeat steps 4 through 7 for petri dish C, but use liquid from container C. Place this dish in the shoe box.
10. Cover the shoe box with its lid and put it in a warm location in the room.

Day 2

11. Remove the petri dishes from the box and observe them to see if any seeds have germinated. (If germination of a seed has begun, the seed coat will be broken and white growth will be projecting from it.) Record the number of seeds that have germinated in Data Table 2 under day 1. If the paper towels are no longer moist, dampen them with drops of liquid from the appropriate container. Return the seeds to the shoe box and replace the lid.

Days 3, 5, and 7

12. On days 3, 5, and 7 examine the petri dishes and count the total number of seeds that have germinated in each dish. Record the numbers on Data Table 2 in the appropriate rows and columns. Moisten the paper towels as needed, return the dishes to the shoe box, and replace the lid.

Day 9

13. On day 9, count the total number of seeds that have germinated in dish A, and record these numbers under day 9 on Data Table 2. Using your metric ruler, determine the length of each shoot. Average the lengths of the shoots from dish A by adding the lengths of all shoots, then dividing the sum by the number of germinated seeds in that dish. Record this average length on Data Table 2.
14. Repeat step 13 for petri dishes B and C.
15. Dispose of the seeds as directed by your teacher. Rinse out the petri dishes with tap water.

Data Table 2: Number of seeds germinated

	Day 1 number of seeds germinated	Day 3 number of seeds germinated	Day 5 number of seeds germinated	Day 7 number of seeds germinated	Day 9 number of seeds germinated	Day 9 average length of shoots
Petri dish A						
Petri dish B						
Petri dish C						

Analysis

1. Calculate the percentage of seeds that germinated in each petri dish by dividing the number of seeds that germinated by 10. Move your decimal two places to the right to give you a percentage.
2. In which of the dishes was the average shoot length the greatest?
3. In which of the dishes was the average shoot length the smallest?
4. Using three different-color pencils, create a bar graph that compares the percentage of germination in these three different petri dishes. Label your x-axis and y-axis and give the graph a title.
5. Using three different-color pencils, create a bar graph that compares the average shoot lengths in these three different petri dishes. Label your x-axis and y-axis and give the graph a title.
6. Based on your analysis, write a letter to the county extension service in Hillgroth that explains your findings and relates them to the reduction in crops. Use the evidence you gained in your experiment to back up your statements. Thoroughly explain how you arrived at your conclusions. Give some recommendations for improving radish seed germination and growth in Hillgroth.

What's Going On?

Most seeds cannot survive in water with a pH less than 5. Radishes generally thrive at a pH of 5.5 to 7. The rainwater in Hillgroth, which has a pH of 4, dramatically lowers germination rate as well as rate of growth. Both the rainwater from Bootlap and the distilled water were within a pH range that works well for radish seeds. The experimental results indicate that acid rain caused by local pollution could reduce crop yield.

Want to Know More?

See Our Findings.

OUR FINDINGS

EFFECTS OF ACID RAIN ON RADISH SEED GERMINATION

Notes to teacher: Prior to the experiment, make up the solutions you will need. Dispense the solutions in labeled test tubes to each lab group.

Mold inhibitor: Add 1 part bleach to 4 parts water.

Container A: This represents rain collected from Hillgroth, which is acid rain with a pH of 4. To prepare this, add 5 ml of a 0.01 *M* sulfuric acid solution in 1 liter of water.

Container B: This represents rain collected from Bootlap, and the pH should be 6. Collect a small flask of tap water and test the pH. If your tap water is more basic than 6, add 1 drop or 2 of 0.01 *M* sulfuric acid and test again. Continue adding sulfuric acid until you reach pH 6. If the tap water is more acidic than 6, add a few drops of 0.01 *M* NaOH until it reaches a pH of 6.

Container C: Distilled water

Dispense a few milliliters of mold inhibitor and samples A, B, and C in test tubes for each lab group.

Analysis

1. Answers will vary. Students will find that seeds in Petri dishes B and C had the highest percentages of germination.
2. Answers will vary, but shoot length was most likely longest in petri dishes B and C.
3. Petri dish A
4. Graphs will vary.
5. Graphs will vary.
6. Student letters will vary, but should include statements correlating acid rain to reduced germination and slower rates of growth. The letter should use the data obtained in the experiment to support its assertions. Suggestions for improvement could include better controls on pollution and future testing of air quality.

SAFETY PRECAUTIONS

Review Before Starting Any Experiment

Each experiment includes special safety precautions that are relevant to that particular project. These do not include all the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is necessary that you read and remain mindful of the General Safety Precautions that follow. Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Materials can spill, break, or even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following the basic safety guidelines during the entire experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. For one reason, we want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical.

Read the safety precautions here and at the beginning of each experiment before performing each activity. It is difficult to remember a long set of general rules. By rereading these general precautions every time you set up an experiment, you will be reminding yourself that lab safety is critically important. In addition, use your good judgment and pay close attention when performing potentially dangerous procedures. Just because the text does not say "be careful with hot liquids" or "don't cut yourself with a knife" does not mean that you can be careless when boiling water or punching holes in plastic bottles. Notes in the text are special precautions to which you must pay special attention.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking an unnecessary risk can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the individual experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone. When you are working off site, keep in groups with a minimum of three students per group, and follow school rules and state legal requirements for the number of supervisors required. Ask an adult supervisor with basic training in first aid to carry a small first-aid kit. Make sure everyone knows where this person will be during the experiment.

PREPARING

- Clear all surfaces before beginning experiments.
- Read the instructions before you start.
- Know the hazards of the experiments and anticipate dangers.

PROTECTING YOURSELF

- Follow the directions step-by-step.
- Do only one experiment at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure there is adequate ventilation.
- Do not horseplay.
- Keep floor and workspace neat, clean, and dry.
- Clean up spills immediately.
- If glassware breaks, do not clean it up; ask for teacher assistance.
- Tie back long hair.
- Never eat, drink, or smoke in the laboratory or workspace.
- Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult.

USING EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives or other sharp-pointed instruments with care.
- Pull plugs, not cords, when removing electrical plugs.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.

- Clean up broken glassware immediately.
- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use alcohol-filled thermometers, not mercury-filled thermometers.

USING CHEMICALS

- Never taste or inhale chemicals
- Label all bottles and apparatus containing chemicals
- Read labels carefully.
- Avoid chemical contact with skin and eyes (wear safety glasses, lab apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING SUBSTANCES

- Wear safety glasses, apron, and gloves when boiling water.
- Keep your face away from test tubes and beakers.
- Use test tubes, beakers, and other glassware made of Pyrex™ glass.
- Never leave apparatus unattended.
- Use safety tongs and heat-resistant gloves.
- If your laboratory does not have heat-proof workbenches, put your Bunsen burner on a heat-proof mat before lighting it.
- Take care when lighting your Bunsen burner; light it with the airhole closed, and use a Bunsen burner lighter in preference to wooden matches.
- Turn off hot plates, Bunsen burners, and gas when you are done.
- Keep flammable substances away from flames and other sources of heat.
- Have a fire extinguisher on hand.

FINISHING UP

- Thoroughly clean your work area and any glassware used.
- Wash your hands.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Do not dispose of materials in the sink unless instructed to do so.
- Clean up all residues and put them in proper containers for disposal.
- Dispose of all chemicals according to all local, state, and federal laws.

BE SAFETY CONSCIOUS AT ALL TIMES!