Radish Seed Toxicity Activity

Middle School Lesson Plan - Outline

Summary of Activity

In this activity, students will dose radish seeds with two provided substances (instant coffee and a small packet of salt), and a water control. There are enough supplies in the kit to test a third substance of your choosing (or a mixture of coffee and salt!). Students will then observe the treatment effect on radish seed germination over the course of three days, answer questions about experimental design, make a plot of the number of seeds that germinated for the different treatments, and interpret their results.

Objectives

Understand concepts of experimental design, such as replication, error, and control, independent and dependent variables. Exercise the skill of plotting data on a bar chart and interpreting results. Gain exposure to the concept of toxicology as a field.

Guiding Question:

How can we set up an experiment to compare the toxicity of various substances to radish seeds?

Teacher Background

Toxicology is the study of the harmful effects of chemicals on living organisms. Chemicals are all around us every day- they make up products that are very useful and beneficial (dish soap, lotion, hand sanitizer). However, some chemicals and products can be harmful to humans. Toxicologists often test products and chemicals to make sure they are not harmful to humans or the environment. To do this, we can select model organisms to use for chemical testing (such as the radish seeds in this experiment). By conducting a controlled experiment where we expose the model organisms to the same amount of various substances, we can determine which substances are more harmful than others. In this activity, our goal is to design a controlled experiment, highlighting elements of experimental design, to compare the toxicity of substances.

Materials Provided for Each Student:

* 4 resealable plastic sandwich bags
* 8 paper towels
* 40 radish seeds
* 1 packet of salt
* 1 worksheet

Materials to Share:

* Measuring spoons
* Instant coffee
* Markers (for labeling bags)
* Cups for mixing coffee and water

**Activity (Day 0):** (reference the TEAM Tox videos for additional support, but please note that the amounts in this protocol are specific to the measuring spoon provided)

1. Assemble the test substances: instant coffee (provided), salt (provided), and a third substance or mixture if you choose. Make sure the third substance that you choose is something meant to be eaten or put on your skin to make sure it is safe for you to experiment with!It could be something like soda pop, dish soap, or even hand sanitizer.
2. Prepare the treatment bags.
   1. Put 2 folded paper towels in each of the 4 plastic bags.
   2. Label the plastic bags with the appropriate information:
      1. Bag Number
      2. Name
      3. Date
      4. Chemical (the name of the test substance)
      5. Concentration (how much was added)
   3. Make the coffee treatment
      1. Mix each packet of instant coffee with 6 oz. of water using the measuring cups and popsicle sticks
      2. Measure 1 tablespoon of coffee into the bag labelled “Coffee”
      3. Measure 1 tablespoon of water into the same bag
      4. Seal the bag and mix the liquid inside the bag so that the entire paper towel is damp.
   4. Make the salt treatment by adding 2 tablespoons of water and packet of salt to the bag, and mixing well.
   5. Make your chosen substance treatment – make sure there are 2 tablespoons of liquid total.
3. Put radish seeds into the treatment bags
   1. Count out 10 radish seeds from the radish seed packet and place them on the wet paper towel in one of the bags. Make sure to spread the seeds out so they have plenty of room between them. Once again, seal the bags and remove as much air as possible. Repeat these steps until all of the bags have 10 radish seeds in them.
4. Lay the bags on a flat surface where they will be safe for several days and leave them until tomorrow when you will count the number of seeds that germinate.

**Pause: Let’s think about this experiment and fill out the “Before the Experiment” part of our worksheets!** *This should be covered in the asynchronous video, but could also be a place for teachers to step in if they wanted to lead a discussion.*

Opening question: Generally, what do the students think the purpose of the experiment is?

Let’s think about our experimental design...

* Discuss variables (independent, dependent, controls)
  + Independent variable (what we choose to change) – type of substance
  + Dependent variable (what we measure) – # of seeds that germinated
  + Control variables (what is the same for *all* seeds) – amount of water, procedure, location of seeds, etc.
* Why did the procedure include the control treatment (water)?
  + A control treatment gives you something to compare to. In this case, it tells us how many seeds will germinate *without* any substance added.
  + Example: if you only saw 5/10 seeds germinate when you added salt, you might conclude that the salt caused fewer seeds to germinate. But if you also had a control treatment where only 5/10 seeds germinated, you might conclude that the seeds or one of the other control variables prevented germination, rather than the salt.
* Discuss replicates – what are they and why are they important to experiments?
  + There were 10 seeds for each treatment to give us more evidence and confidence in our conclusions. If one or two seeds are tested, the result could be by chance. But if ten seeds are tested, it is far more likely that the results are correct. Replicates give us more confidence in our results.
* Discuss the importance of keeping good records during your experiments.
  + Good labelling.
  + Writing down the substances that you are testing.
* Discuss some different substances that students chose to test (besides coffee and salt) and why they chose them.
* Hypotheses: What do you think is going to happen in this experiment?

**Activity continued (Day 1-3):**

1. The next day, without opening the bags, count the number of seeds that have germinated (I.e. have little sprouts growing out of them).
2. Write the number of germinated and not germinated seeds in the “Seed Toxicity Results” Table on your worksheet (hint: these two numbers should add up to 10).
3. Repeat this counting for two more days until you have counts for a total of three days and your Results Table is full.

**Activity continued (Day 3):**

1. Follow the instructions on the Data Worksheet and answer the Discussion Questions.
2. Construct a plot to show the results collected in your Results Table.

Results and Discussion:

**Hypotheses**

* What impact did you initially expect the substances to have on the seeds? Were your expectations correct?

**Experimental Design and Observations**

* How did the setup of the experiment and recording observations go? Did you run into any issues?
* Identify conditions that may not have been consistent across different students (ex. light, temperature). How might this have impacted the seeds? Why might control variables be important?
* Discuss other observations students might have had during the experiment

**Sharing Class Data and Conclusions:**

* What do our graphed results tell us?
* What sources of error might there be in the experiment? Experimental error can relate to human actions, the tools we use, or the environment surrounding our experiment.
* What conclusions can we make from the data?
* What might you do differently if you were to perform this experiment again?

Larger Lessons from this Experiment (incorporation of standards):

*MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms*

* In this experiment, the environment of the radish seeds was altered by adding different substances (salt, instant coffee, etc.). Based on the classes’ data, what impact did those substances each have on the germination (growth) of the seeds when compared to the control treatment (water)?
* *Why* might the substances have inhibited growth?
  1. What seeds need to germinate: the right amount of light, oxygen, water, acidity, and the right temperature
  2. **Salt** can prevent seeds from absorbing water, and can prevent new cell growth that is required for sprouting
  3. **Coffee** might make the environment too acidic for the seeds to germinate, and the caffeine in the instant coffee can impact new cell growth
  4. **Other substances** could have different impacts on the ideal seed conditions
* Talk about other examples of environmental factors influencing the growth of organisms (ex. fish in a polluted river or plants in dry soil may not grow very well).
* Could also discuss genetic differences of the seeds – this could explain why some of the seeds in the same bag germinated, while others didn’t. This would also relate to *MS-LS4-4*.

*MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*

* Could bring in an example that ties this experiment to the real world and think about impacts on larger populations and ecosystems.

Potential scenario: There is a meadow, with grass and other plants that feed mice, rabbits, and deer in the area. A company began mining salt next to this meadow, and after it rains in the area, some of the salt washes into the meadow. Based on this seed experiment, what kinds of consequences do you think this salt run-off will have on the populations in the meadow ecosystem over time?

*MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

* In the scenario above, ask students to brainstorm ways to monitor and minimize the salt contamination in the meadow to prevent harm to the ecosystem.
* It might be helpful to tell them that there are tools called salinity meters that can measure salt concentrations in soil or water.

Toxicology note on dose-response and how relevant our model organism is to humans:

In this experiment, the instant coffee decreased seed germination, but people drink coffee all the time! Does that mean that coffee is bad for humans?

This is a great question and is often asked by scientists when they do toxicity studies using plants, animals, or even bacteria. In general, humans do share some biology with other animals and plants, like how our cells and genes work, but there are also structural features that set us apart. This means that we will probably respond to a substance, like coffee, differently than a plant seed. The amount of coffee is also very important to think about. For the seeds in this study, we gave them *too much* coffee, so they were no longer healthy. But for humans, the amount of coffee that would make someone unhealthy would be different.