

Exploring Seed Germination

by Brad Williamson

Background:

Seeds are very remarkable. Laying dormant inside the seed is an embryo plant. Packed with the embryo is enough stored chemical energy to power the young seedling until it can capture its own energy from the sun by the process of photosynthesis. The timing of germination or the breaking of the dormancy is important to the success of the young seedling. For instance, milkweed seeds that are produced in late summer and fall are carried on the wind, away from the parent plant. They fall to earth in all sorts of environments. If the seed goes ahead and germinates immediately, the young milkweed plant will not be able to produce flowers and seeds before the onset of frosts and winter (at least in the northern U.S.) Milkweed seeds actually don't germinate until they have experienced long periods of low temperatures. In the spring when the soil is moist and the soil temperature is warm enough a new generation of milkweed to begin. The seed has to somehow respond to signals in its environment in order to germinate at appropriate times.

Many environmental factors can affect seed germination. Light intensity, day length, night length, light color, water, water quality, gravity, crowding, temperature, nearby plants (by chemical agents), genetics, oxygen availability, seed condition, seed age, seed coat condition, seed size and other environmental conditions can have measurable effects on seed germination. Gardeners, worldwide, have a number of ideas of other environmental factors that may influence germination such as the phases of the moon, tidal effects, and planting with companion seeds. Seed germination is a good topic for scientific exploration since it is easy to observe and there are so many obvious and not so obvious environmental factors that can affect the germination.

In order to germinate and break dormancy a seed has to absorb quite a bit of water. In nature seeds absorb this water from the soil. Planting seeds in pots of soil is certainly one way to study their germination and a lot can be learned with controlled experiments. However, observation of soil germinated seeds is not easy-one can only observe the top half of the newly emerged plant. The newly developing roots are equally important when studying seed germination. The method described here involves germinating seeds on a moist filter paper that has a constant source of water. By germinating seeds on a moist paper the root growth can be observed and measured more easily. Also, large numbers of seeds can be tested in a small amount of space in a short period of time.

A method for exploring seed germination:

Materials:

9 cm Petri dish

10 seeds per chamber (small seeds such as radish, alfalfa, lettuce, weed seeds, etc.)

9 cm filter paper disk

plastic acetate grid

water reservoir (plastic shoe box, the bottom of a two-liter bottle, etc.)

magnifier

forceps

Procedure:

1. Construct a seed germination chamber by first placing the plastic acetate grid on the top petri plate. Secure it in place with a drop of water. Write your name, date and seed type near the top edge of the filter paper disc with a pencil or waterproof ink. Place the filter paper disc over the top of the plastic acetate grid. You may have to trim the paper to fit flat in the petri dish. Wet the paper to hold it in place. It will become transparent so that you will be able to see the grid lines underneath.
2. With the arrow on the grid pointed up, add ten seeds evenly spaced across the line that is the top of the grid. Refer to figure 1. The seeds will usually stick to the wet surface of the filter paper. If seeds fall off during the study simply place them back on the moist filter paper. Make sure that you orient the seeds so that the micropyle is facing down. The root will usually emerge from this area since it is the weakest point in the seed coat. Place the bottom of the petri over the assembly to complete the germination chamber.

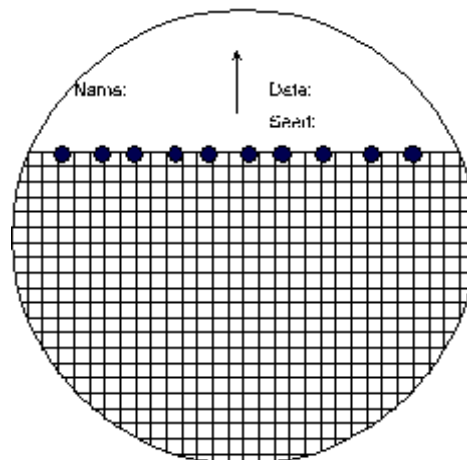


Figure 1

1. Place the chambers leaning on edge in a water reservoir. Maintain about two or three centimeters of water in the water reservoir throughout the experiment. The water in the reservoir will wick onto the surface of the filter paper, keeping the filter paper wet and providing an ideal environment for seed germination.

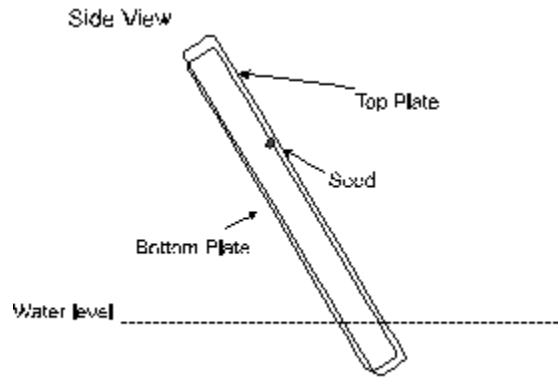


Figure 2

Collecting Data:

Data is information that is collected with a purpose. It can be *qualitative* data—data such as color, appearance, relative size, etc. or it can be *quantitative* data—data that is measured and assigned numerical values. Generally, quantitative data is more reproducible than qualitative data. For example, when your description of how green (qualitative data) a leaf is will probably differ from your neighbor's description—even when you are describing the same leaf. However, if you were to both measure the length of the leaf in millimeters (quantitative data), your measurements would probably be in close agreement. The above procedure is good for collecting both kinds of data.

Qualitative

Color of seeds. Seeds come in all kinds of colors. Trying to categorize colors can be difficult just ask anyone who has tried to match house paint. Often by selecting a specific color closest to your seed and describing that color by the shade you'll be on your way.

Quantitative

Number of seeds germinated per day. Seed germination can be measured and communicated by counting the number of seeds that have germinated in a given time period. For instance if 6 seeds germinate the first day of your investigation and 3 the next out of a total of 10 seeds then you could communicate that the germination rate was 60% after one day and 90% after two days.

Color of cotyledons. Refer to the above.

Length of root of each seedling in mm. This procedure was actually designed to make it easy to measure the length of germinating roots. Since the seeds are placed on a grid. You can simply count the number of times that a particular root crosses or intersects a grid line (vertical or horizontal). Plug that number into the following formula to calculate root length.

$$\text{Root length (mm)} = \text{number of intersections} \times (0.7857 \times \text{the size of the grid in mm})$$

For example, if a root crosses a 3 mm grid 24 times:

$$\text{Root length} = 24 \times 2.3571\text{mm}$$

$$\text{Root length} = 56.6 \text{ mm}$$

Collect root length daily. Graph the rate of root growth.

Appearance of seed. Describe the shape and texture

Size of seed in mm. Measure the size in millimeters.

Color of hypocotyl. This is the stem of the new plant. Its color can vary

Length of hypocotyl. Measure with a ruler or use a different background grid. Measure daily.

Carry out an Investigation:

1. Using the background as a guide decide on an environmental factor that might affect the germination of seeds. A sample question might be: "Does light affect seed germination in lettuce seeds?"
2. Develop a hypothesis that will help you to design an experiment using the method described above. A sample hypothesis might be: "If light is necessary for radish seeds to germinate then lettuce seeds germinated under room light should have a higher germination rate and faster germination than radish seeds germinated without light." You might add another hypothesis about root growth rates or other factors. A single experiment can measure more than one outcome. It's important, though, to keep the number of tested variables (light) to one when you are just starting out learning to do science.
3. Design your experiment to control your variables. A sample experiment might be: "Set up two identical petri plates with 10 seeds of lettuce each as describe in the above procedure. Keep both at room temperature but cover one with aluminum foil to block out all light. Keep both plates under a fluorescent light. Grow the plates for 4 days, taking data for seed germination, root length, and cotyledon color for each day "
4. Design and construct data tables for data collection. Collect the data over 4 days.
5. Present your data. Develop and present your conclusions based on your data.

Teacher notes:

1. The student procedure purposely leaves out description of terms needed for understanding. You may introduce the terms as needed or as the student attempts to communicate use the opportunity to introduce the importance of scientific terminology. Vocabulary needed for this procedure: cotyledon, hypocotyl, radicle, root, micropyle, hilum, seed coat, seed, germination, embryo.
2. The background has a number of environmental factors listed that affect seed germination. The idea of this investigation is to have students develop or design their own lab to investigate one or more of these factors. This method is particularly good for quantifying root growth. Some students may want to compare this method to germination experiments that involve soil. This lab is also applicable as a performance assessment to determine students abilities to design and carry out a laboratory investigations. A related assessment can be found at:

http://www.gene.com/ae/AE/SH/NSTA_NOR/morris_seeds.html

Seeds of all kinds can be used but they should be small to fit onto the petri plates. Suggested seeds include: Wisconsin Fast Plants, radish seeds, lettuce, alfalfa, clover, seeds from various weeds such as mustards, plantain and dandelion.

- Different sizes of grids can be designed for this investigation. The 3-5 mm size is easiest for students to count but a 1 mm grid may provide more precise measurements.
- There is no particular reason for 10 seeds to be tested on each plate. The number can be higher or lower. What is important is that the students realize that the seeds represent a population and by have a reasonable sample variation in the population is considered.
- This is a good lab to utilize stem and leaf diagrams as well as box and whisker plots for comparing data sets. Diagrams, data tables, and graphing templates are not provided so that the student will be encouraged to develop their own diagrams, tables and graphs as part of their laboratory work.
- This lab also is a good take-home lab since there are minimal safety precautions.

References:

Frame, Kathy. "Involving your Students in Cutting-Edge Biological Research." Proceedings of the 19th Workshop/Conference of the Association for Biology Laboratory Education. 1997. 351-355.

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