Seed Germination Demonstration and Plant Biology Discussion

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Introduction:
Most crops are grown from seed. The seed industry in the US is a major agricultural industry employing tens of thousands of people. The value of agricultural seeds sold in the US, Mexico, and Canada each year is worth **billions** of dollars. Seed production for propagation is a major industry in California, Iowa, Minnesota, Oregon, Washington, and Idaho.

The exercise described below is designed to give students a hands-on experience with seeds that can be conducted in a classroom or at home. The experiment can be used to discuss related issues like food security, global warming, human health, genetic engineering etc.

Materials:
1 germination pouch per student or group.
Each pouch needs:

- A plastic bag (1 qt works well)
- Thin piece of cardboard a little smaller than the bag
- Newspaper to fit along the top, folded over twice.
- 25 cabbage or lettuce seeds.

Assemble germination pouch by poking many small holes along the bottom of the newspaper pocket. Then attach the pocket to the top of the cardboard. Insert this piece into the plastic bag.

Objectives: Observe germination and early seedling growth of a common vegetable: cabbage.

Procedure:

1. Scatter 25 seeds uniformly in the paper pocket at the top open end of the germination pouch (see picture below).
2. Hydrate the paper by pouring a few ounces of tap water directly into the pouch. After the paper in the pouch is fully hydrated, pour out excess water. It is OK if a little excess water remains in the pouch but it should not be full of water. The paper will hold sufficient water for the seeds to germinate.
3. After planting, keep the pouch upright at room temperature. Light is not required for germination but will improve seedling growth after the cotyledons develop and turn green (produce chlorophyll).
4. Observe and record the number of seeds that germinate each day of your experiment until no more seeds germinate for at least two consecutive days.
5. Use your data to calculate a mean time to germination. The mean time to germination (MTG) can be calculated, as $\Sigma(N_iT_i)/\Sigma(N_i)$ where N_i is the number of newly germinated seeds at time T_i after imbibition.
6. Also calculate the germination percentage for this experiment.
7. Record the answers to the following questions.
    a. What kind of vegetable seeds are these and how is the crop used as food?
    b. How long did it take the first seed to germinate?
    c. When did the last seed germinate?
    d. The mean time to germination is often used to assess seed vigor or in other words: how well seeds germinate as opposed to whether or not they are simply alive.
    e. Do root lengths differ among seedlings?
    f. Is this because some roots grow faster or some seeds germinated earlier than others and the roots had a longer time to grow and develop?
    g. How can the seedlings germinate in the bag on paper with no fertilizer?
8. *(Optional)* When you have collected the data for this experiment, you may carefully transplant the plants into your garden or another container. You do not necessarily have to remove the seedlings from the paper for successful transplanting, since the paper is biodegradable.

Teaching points:

Seeds need water to germinate but not soil. Seedlings contain sufficient nutrients to germinate and grow into a healthy seedling on paper without soil. Most agricultural crop seeds germination in the dark and do not need sunlight.

After the germination demonstration has concluded, seedlings can be carefully singulated by removing the paper from the plastic pouch and tearing the paper into strips with the seedlings intact for planting outdoors. Some thinning may be required to give plants room to grow.

Viability is a measure of whether or not seeds are alive or dead and is usually recorded as a percentage of the total seeds that germinate over a particular length of time and at a specific temperature. Vigor is a different concept that refers to how well viable seeds germinate. Vigor can be measured in many ways but is commonly measured by how fast seeds germinate, expressed as a rate of seeds per day, or how well they germinate under stressful conditions such as high or low temperatures or water stress.

Seeds are living miniature plants in an arrested state and contain the same parts as larger plants: roots, stem, apical meristems, and cotyledons or "seed" leaves. The seed leaves develop chlorophyll, the green pigment in plants, soon after germination and begin fixing carbon dioxide from the atmosphere while giving off the oxygen we need to breath. The carbon dioxide is made into organic (carbon containing) molecules that the plant uses to grow and develop. The majority of plant dry weight is made up of carbon derived from the atmosphere. Plants are vital to our existence because they provide the food and fiber animals and humans need and the oxygen we all need to breath.

Other resources: The Ohio State University seed identification website http://www.oardc.ohio-state.edu/seedid/. Vegetable Seed production website at Virginia Tech: http://www.hort.vt.edu/Welbaum/seedproduction/