The Effect of Vortexing on the Sprouting Rate of Fast Plant Seeds

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Introduction

The objective of the experiment was to gather information regarding the effect of vortexing on the growth of Wisconsin Fast Plant seeds. According to the *Encyclopedia Britannica*, in seeds, the testa, also known as a seed coat, is a clear outer covering that protects the embryo from the environment (2016). However, the seedling must also break through it in order to germinate and sprout. The website *Plant Physiology* stated in one of its published papers that in order for a seed to germinate, it has to break through dormancy with the help of certain agents (Debeaujon, Léon-Kloosterziel, & Koornneef, 2000). Therefore, if the testa is worn down, as the team assumed the vortex treatment would do, the team believed that it would take a shorter time for the seed to germinate and sprout. The team was inspired to perform this experiment based on one in ScienceDirect involving the effect of vibrations on the yield of peach trees; the experiment placed electric vibrators on the trunks of the trees. The team wanted to see if vibrating the seeds before they were even planted would have an effect on plant development, specifically, the time it took for the seed to sprout.

Hypothesis

Alternate:

Vortexing Wisconsin Fast Plant seeds before planting will increase the speed at which the seeds will sprout.

Null:

There will be no significant difference in the speed of sprouting between seeds that were vortexed and ones that were not vortexed.

Materials/ Equipment/ Facilities

Materials	Source
36 Fast Plant seeds	Mr. Roche
Masking tape	Mr. Roche
Potting soil	Mr. Roche
Laboratory sand	Mr. Roche
Water	Mr. Roche
Parafilm	Mr. Roche
12 sticks	Mr. Roche

Equipment	Source
Vortex machine	Mr. Roche
12 film canisters	Mr. Roche
Lamp (light source)	Mr. Roche
Digital camera	Mr. Roche
Time-lapse camera	Mr. Roche
SD card	Annie
Batteries	Mr. Roche
Tripod	Mr. Roche
Test tubes (for vortexing seeds)	Mr. Roche
Stopwatch application	Brianna
Sharpie	Emily
Ruler	Mr. Roche

Facilities	Source/Location
Research lab	HTHS
Biology classroom	HTHS
Computer lab	HTHS

Timeline

10/20/16 - Received supplies (time-lapse camera, batteries, film canisters, large container to hold canisters, soil, water); began setup for planting; inserted batteries and SD card in time-lapse camera; filled 12 canisters with soil; soaked the wicks in water and poured water into each canister.

10/25/16 - Cleared out space in research lab for experiment; set up time lapse camera on a tripod; marked each skewer, and put them in each film canister.

10/26/16 - Received 36 Fast Plant seeds and laboratory sand; used the vortex mixer to vortex 12 seeds with each other, and 12 seeds with sand; planted control and experimental groups, one of each group in each canister.

10/26/16-11/15/16 - Watered the plants every few days by filling up the container with water, allowing wicks to take water into the soil.

11/18/16 - Took out SD card with pictures; marked down hours before seeing sprouting for each seed.

11/22/16 - Analyzed data.

Experimental Design Diagram

Title

The Effect of Vortexing on Speed Sprouting

Hypotheses

Alternate:
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Null:
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Independent variable

Type of Vortex Treatment

Vortex Treatment?	Vortex with only seeds	Vortex with laboratory sand	No treatment
# of trials (seeds)	12	12	12
Control?	No	No	Yes

Dependent Variable

Time (in hours) for seeds to sprout (seen above soil)

Operational definition of dependent variable

Time for seeds to sprout (in hours) = [(Number of pictures before seed appearing above ground minus 6)/2]

Constants

Soil type
Light exposure (intensity, time period, type)
Water (frequency, amount, type)
Temperature

Experimental Setup, Graphics, Illustrations

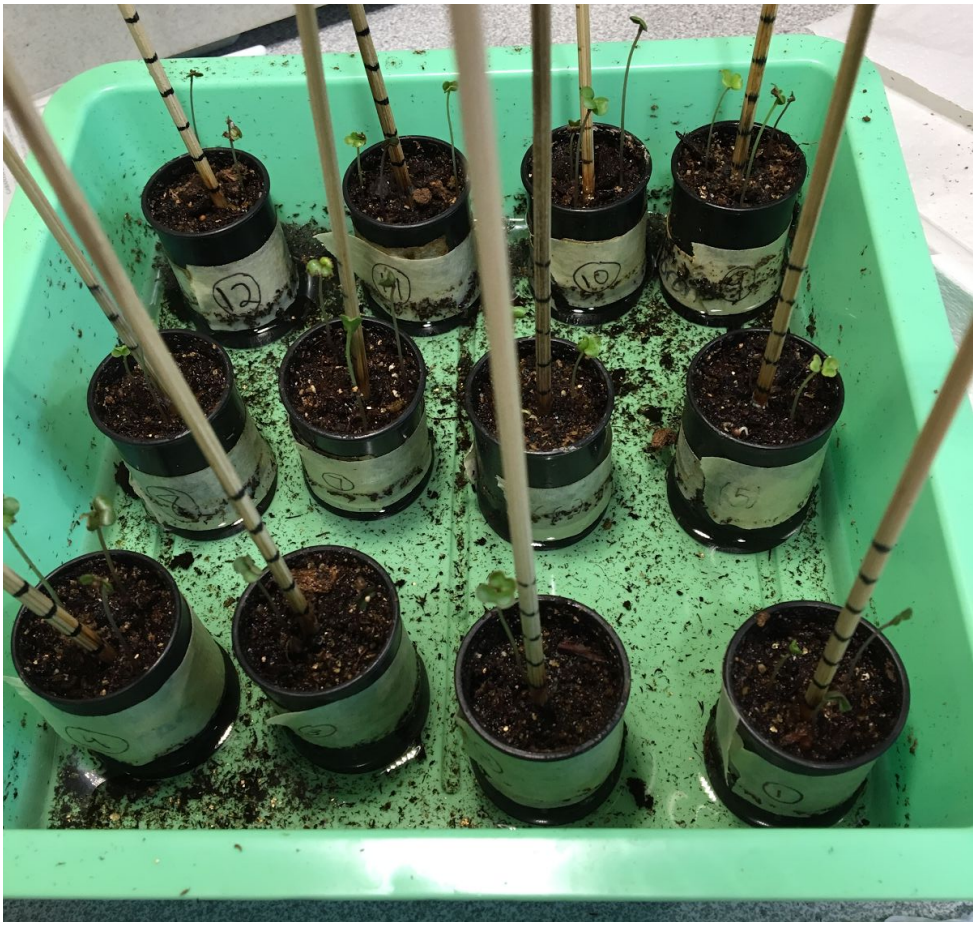

FIGURE 1: Plants Sprouting (control group faces forward)

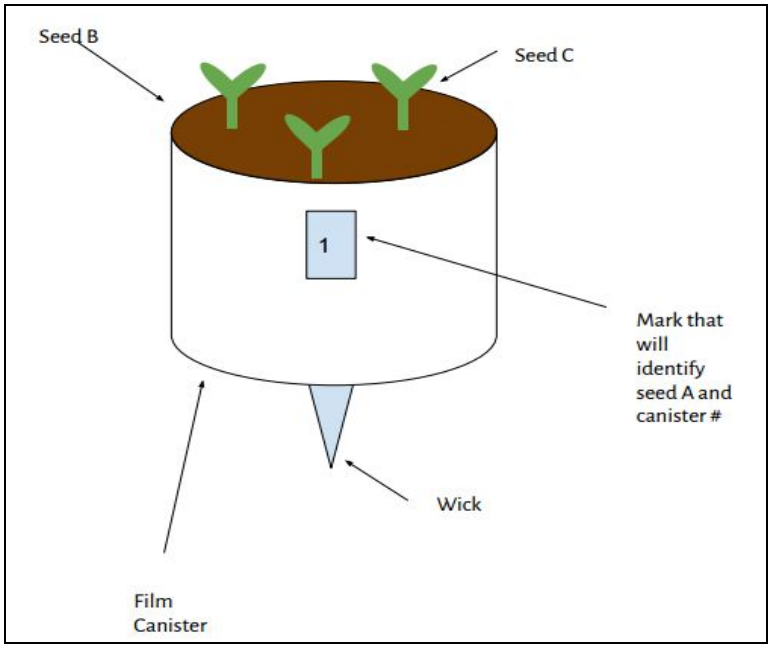

FIGURE 2: Illustration of Setup for Individual Canister

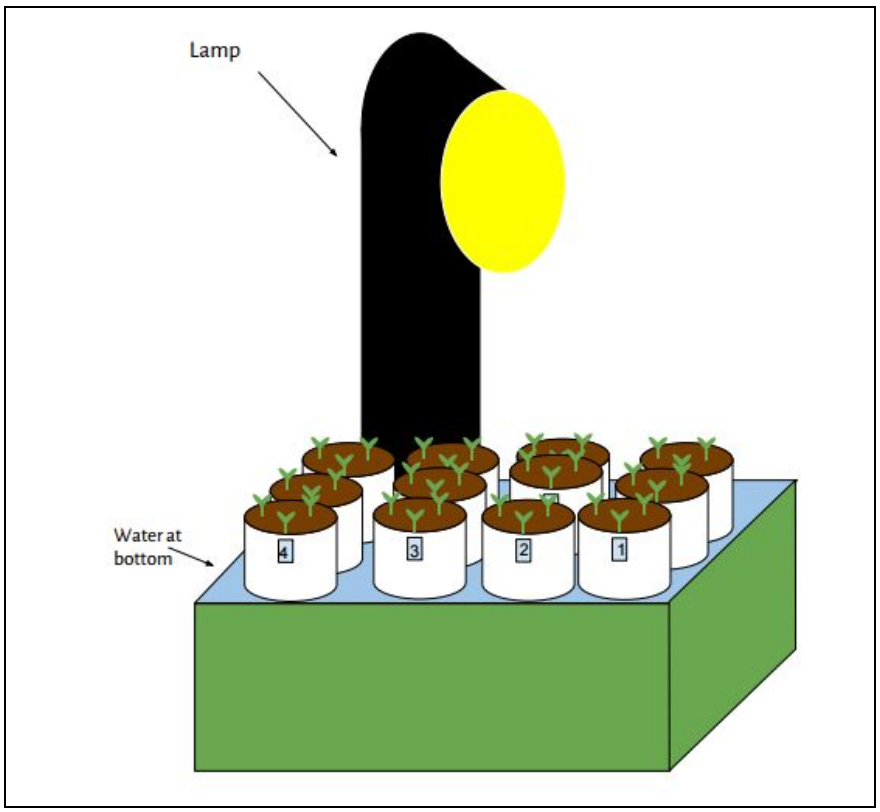

FIGURE 3: Illustration of Complete Experiment Setup

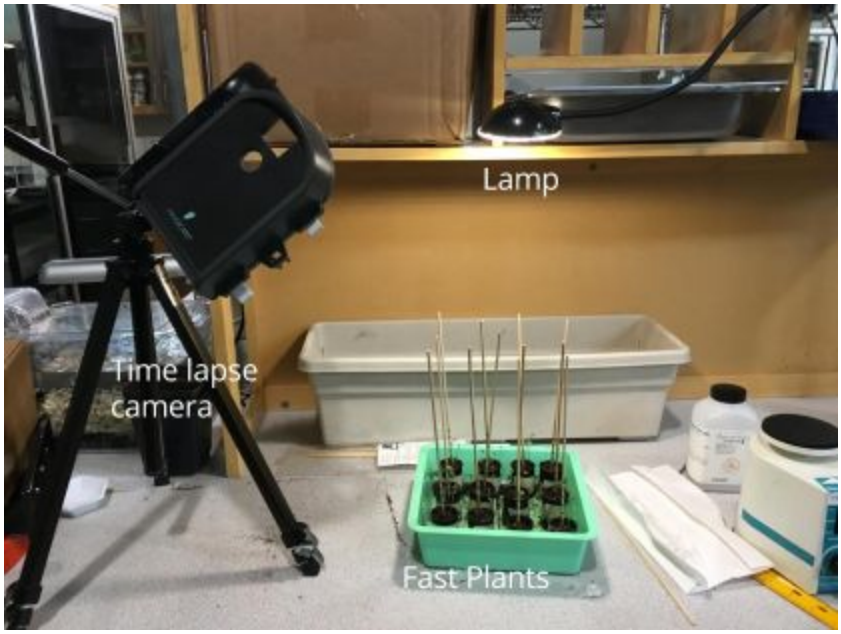

FIGURE 4: Photo of Complete Experiment Setup

Procedure

1) Place 12 Fast Plant seeds in a test tube and seal it with parafilm.
2) Set vortex mixer to "touch" and press test tube to the pad for one minute, timing with a stopwatch application.
3) Repeat steps 1-2 but with laboratory sand also in the test tube. Set aside 12 untreated Fast Plant seeds; this is the control group.
4) Label 12 empty film canisters with numbers 1-12.
5) Place a wick through the hole in the bottom of each canister.
6) Fill the 12 film canisters with potting soil.
7) Moisten the soil in each canister by adding water to the top and pressing lightly with fingertips.
8) Place the 12 film canisters in one larger container, leaving approximately the same space in between each one.
9) In each canister, place one seed from each of the 3 groups in a clockwise circle. Using a marker, mark where the control group seed has been placed by drawing a vertical line on each canister.
10) Lightly sprinkle potting soil over each canister, completely covering the seeds in a thin layer.
11) Using a black marker and a ruler as a guideline, draw five tick marks on a skewer, starting ~2 cm above the pointed end. The five tick marks should be evenly spaced 1 cm apart. Repeat for 12 skewers.
12) Insert one skewer into the center of each of the 12 canisters. The bottommost tick mark should be at the soil level.
13) Fill the large container with ~1 cm of water. The wicks in each canister will draw water into the soil.
14) Insert batteries and SD card and set up the time-lapse camera on a tripod facing the experiment.
15) Turn on the light source (overhead lamp).
16) Turn on the time-lapse camera to record the observations.
17) Pour water in the container around every other day to allow plants to draw in water.
18) After seeds have sprouted and grown, remove SD card from time-lapse camera to observe the experiment results.

Findings

TABLE 1: Time in Hours (Dependent Variable) For Seeds to Sprout (Quantitative)

Film Canister #	Control Group Time (hrs)	Vortex with Seeds (Independent variable 1) Time (hrs)	Vortex with Sand (Independent variable 2) Time (hrs)
1	91	65.5	86
2	N/A	68	N/A
3	37	37	51
4	69.5	79.5	67.5
5	N/A	Did not plant	50
6	N/A	60	71
7	59	69	67
8	65	51	67.5
9	68	79	71
10	67.5	97	70.5
11	83	95	70.5
12	N/A	79.5	85

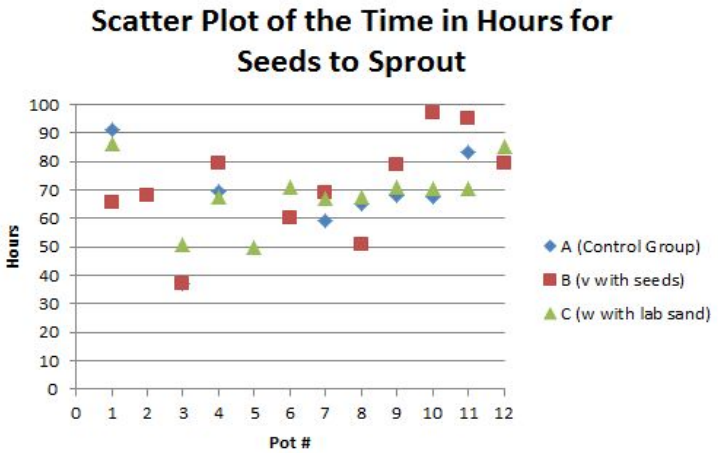

FIGURE 5: Scatter Plot of the Time in Hours for Seeds to Sprout

TABLE 2: First Seed Type to Sprout by Canister (Qualitative)

Film Canister #	First Seed Group to Sprout
1	Vortex w/ seeds
2	Vortex w/ seeds*
3	Vortex w/ seeds and control group
4	Vortex w/ sand
5	Vortex w/ seeds*
6	Vortex w/ seeds*
7	Control group
8	Control group
9	Control group
10	Control group
11	Vortex w/ sand
12	Vortex w/ seeds*

*In each of these groups, at least one plant never sprouted, and one was never planted.

TABLE 3: Summative Data Table For Time (in Hours) for Seeds to Sprout (Quantitative)

	Control Group	Vortex with Seeds	Vortex with Sand
Mean*	67.50	70.95	68.82
Standard Deviation*	16.06	17.83	11.18
Variance*	257.93	318.07	125.06
n*	12	12	12

*Data excludes the seeds that never sprouted.

TABLE 4: Table of the Treatment Groups' Sprouting Status (Qualitative)

	Control Group	**Vortex with Seeds**	**Vortex with Sand**
# of Times Group Sprouted First	4.5*	5.5*	2
Is it mode of data set?	No	Yes	No

*Control group and vortex with seeds were tied for first in canister 3.

The average time it took for the seeds to sprout did not vary greatly between the different groups, and the range of the sprouting times was slightly less than three and a half hours. Furthermore, 4.5 seeds from the control, 5.5 from the seed vortex, and 2 from the sand vortex group sprouted first of the other plants in their canister, leaving only a difference of one between control and seed vortex and, despite the authors' supposition that it would sprout first, sand vortex lagging behind. Therefore, the hypothesis was not supported by the observations; vortexing the seeds did not have a positive influence on time it took to sprout, as the two experimental groups took an overall longer time to sprout than the control group.

Several factors may have affected the integrity of the experiment. Mainly, a combination of human error and natural variability in the materials slightly altered the constants of the experiment. For example, the composition of the soil in each canister was not uniform because there were different amounts of each component in the potting mix bag, and the amount of soil that went in each canister was measured visually, not by making sure that they each had the same mass. In addition, soil density was slightly different because the pressure on the canisters was exerted by an irregular human hand. Also, since the wicks that were used were reused from a previous experiment, it is possible that some were not as effective as they could have been. Their sizes were also not uniform, perhaps drawing up more water for some canisters than for others.

The unexpected outcome of the experiment may be because the seed coat is thick enough to withstand some outside forces. In the real world, the data collected from this experiment could mean that seeds are not greatly affected by vibrations in the earth, including earthquakes and other natural disasters, or by human-induced circumstances such as being transported in trucks.

Bibliography

Debeaujon, I., Léon-Kloosterziel, K. M., & Koornneef, M. (2000). Influence of the Testa on Seed Dormancy, Germination, and Longevity in Arabidopsis. Retrieved November 20, 2016, from http://www.plantphysiol.org/content/122/2/403

The outer coating of a seed is known as the testa and protects the embryo against outside environmental conditions. It controls germination through dormancy imposition and limiting the harm from other activities. The research group conducted an experiment on how the pigmentation of testa would affect the plant Arabidopsis. The ones with most mutants had reduced dormancy, related to the defects of the testa layers. Seeds with missing layers in the testa had affected dormancy levels, and ones with structural defects deteriorated faster with natural aging at room temperature.

Leubner, G. (2005). Seed Dormancy. Retrieved November 20, 2016, from http://www.seedbiology.de/dormancy.asp

Seed dormancy is defined as the period of time when circumstances are viable for a seed to sprout but it does not do so. During this time, it is protected by a clear surrounding layer called the testa; however, testae can also help induce dormancy because of the "mechanical resistance" on the seed, preventing the plant from germinating. In order to grow, the seedling must first break through the testa, ending what is known as "coat dormancy." One study on plants with mutated testae shows that certain changes in seed coats reduce dormancy; this is the basis of the experiment, which aimed to show how a weakened testa might allow dormancy to end faster.

Mizutani, F. (2006). The effect of trunk electric vibration on the growth, yield and fruit quality of peach trees (Prunus persica [L.] Batsch). Retrieved November 21, 2016, from http://www.sciencedirect.com/science/article/pii/S0304423806000987

This website provides an abstract on a research experiment about the effect of vibration on the growth, yield, and fruit quality of peaches. This was done by using an intermittent electric vibration attached to the trunks of peach trees. The vibrations reduced the shoot length, though it had no significant effect on fruit weight. In another experiment, vibrators were attached to the branches after pruning. The regenerated shoots had more than 500% reduction in length compared to the untreated ones.

This article serves as the inspiration for the vibration aspect of the experiment. The fast plant experiment was based on vibrations as well, although they were administered at a different stage and with a different source.

Testa. (n.d.). Retrieved November 19, 2016, from https://www.britannica.com/science/testa

"There are at least three ways in which a hard testa may be responsible for seed dormancy: it may (1) prevent expansion of the embryo mechanically (pigweed), (2) block the entrance of water, or (3) impede gas exchange so that the embryos lack oxygen."

Many seed coats also possess a waxy covering. Often, seed coats are permeable to water, but not to oxygen, making it difficult for some plant seeds to germinate. The most difficult plants to work with are those in which the embryos can remain dormant even after the seed coat is removed and the seed is in ideal growing conditions.

Wisconsin Fast Plants Program. (n.d.). Retrieved November 22, 2016, from http://www.fastplants.org/

Dr. Williams bred *Brassica rapa* with related crucifer species, resulting in fast plants, a part of the crucifer family, which includes plants like cabbage and turnips. They are suitable for laboratory and classroom use because of the speed of flowering, the ability to produce seeds at high planting density, small size (up to 20 cm tall), and the convenience to grow in any environment (fluorescent light bulb and potting soil). The life cycle of these fast plants is about five weeks, and using them has led to advancements in cellular and molecular research.