**Freeze, Seed!**

**A Soybean Project**

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**Holy Family 2018 Science Fair**

**January 22, 2018**

**Abstract**

For this experiment, we conducted a trial to find out what would happen if we grew seeds that were frozen versus seeds that were left at room temperature. Our hypothesis was that the frozen seeds would grow at a slower pace than the normal seeds. To conduct this experiment, we planted twenty-five frozen seeds into twenty-five soil pods in one greenhouse. We took twenty-five room temperature seeds and planted them in twenty-five soil pods in a second greenhouse. After that, we exposed both greenhouses to six hours of LED grow light each day. Every Monday and Thursday, we fed them five milliliters of water, and every Tuesday and Friday, we measured the plants’ height in inches, and documented the measurements and appearance of the plants. We conducted this experiment over three weeks.

We discovered that our results were not too far off from what our hypothesis stated. The room temperature seeds grew six sprouts within a few days. Meanwhile, the frozen ones only grew two sprouts within the same amount of time. On the last day of taking measurements, we discovered that two of the room temperature seeds and two of the frozen seeds had both just sprouted. The new plants were measured and documented, as well. The data that we collected can be found in the ‘Data and Graphs’ section of this report.

The quality of the frozen seed plants was not very different from the room temperature plants, although the quantity of the seeds that sprouted was two-thirds less for the majority of the experiment. Therefore, our hypothesis was only partially correct. We found out that the cold temperature does not significantly affect the size or speed of the growth, rather, it affects the chance that they will sprout at all. This project taught us that farmers can use the seeds that were left in the freezing temperatures, but they will have to plant more of them if they want the same amount of crops that would grow in a normal year.

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**History, Background, and Uses**

 Soybeans originated in Asia, and were introduced by Chinese farmers around 1100 B.C. In the 1900s, soybeans were introduced into Western culture and used as a source of protein and oil. Besides being a great source of protein for humans, soybean protein is widely used in commercial feeds for animals. As growing soybeans in the United States became more popular, it was discovered that soybeans also provided nutrients that benefited the soil for other crops. Many farmers grow soybean plants on their farms to ensure healthy soil for other crops. This process is called crop rotation.

Soybeans have a lot of health benefits for humans, and are found in about 80% of the food that is consumed in the U.S. The most popular foods that soybeans can be found in are: chocolate, margarine and protein bars. In fact, eighty-six percent of most protein bars are soybean. Soybean seeds and plants are used in so many ways that they have become a necessary resource in the world, and not just for food. Soybeans are used to make coating on tablets and capsules for medications. They are also used to make paintballs and some car parts, like gear shift knobs and window frames.

Soybeans are such a vital resource throughout the United States and the world, that there are a number of professional organizations focused on spreading information and funding to farmers. Three of the largest organizations are: The American Soybean Association, The United Soybean World, and The United Soybean Board. We decided that we wanted to do this project to find out if the condition of a soybean seed (room temperature or frozen) affected the quantity and quality of soybean plant growth.

We spoke with Larry Janchar, a local farmer from Marshallville, Ohio that has been growing soybeans for thirty years. He expressed his concern about the drastic changes in weather over the last decade. He reported that increases in extreme temperatures during the summer and winter months are creating many challenges for farmers. Some fears are that the crops will be delayed or not as plentiful due to colder weather. In addition, hot, dry summers can cause dry soil, leading to fewer, drier crops, and the risk of spreading wildfire.

This experiment focuses on one of the environmental factors above. According to the Popular Science® website, as the Arctic Ocean is getting warmer, atmospheric patterns are creating a change in the winter temperatures, causing our North American winters to get colder. We found a map in the same article that shows the loss of crops, including soybeans, across the United States due to the colder temperatures in the winter and spring. With these changes in the weather, we asked ourselves, “What would happen to growth rates and quality of soybean plants if farmers had to use seeds that were exposed to extreme cold conditions?” This is important because some crops are failing due to extreme temperatures. We asked Mr. Janchar what temperature he keeps his seeds at before he plants them. He told us this: “I like to keep my seed house cold. I usually keep it at 20℉-25℉ (-7℃ to -4℃).” Because of the colder temperatures during the last few winters, we froze our seeds to see what effect that would have on the crops. That is why this project is important.

**Purpose/Question**

Does the condition of a soybean seed (room temperature or frozen) affect the quantity and quality of soybean plant growth?

**Variables**

 The **Dependent Variable** is the change that occurs because of the independent variable. The dependent variable in this experiment was the height of the soybean plants.

 The **Independent Variable** is the variable that changes in an experiment. The independent variable in this experiment was the temperature that half of the seeds were kept in (-20℃) for two weeks before being planted.

 The **Controlled Variables** are the variables that stay constant and do not change. In this experiment, the soybean seeds, the amount of liquid provided, the soil type, greenhouses, clay pots, the water, the amount of time under the grow lights, and the wavelength of the grow lights were all the controlled variables.

**Hypothesis**

The soybean seeds that were frozen will produce plants that grow at a slower rate when compared to soybean seeds that were kept and planted at room temperature.

**Soybean Plant Anatomy**

**Key Terms**

* **Leaves**​ are usually part of the plant that come off the stem and are key structures for photosynthesis.
* **Seedpod**​ is a vessel that holds seeds of a plant
* **Stem**​ is the structure that supports a plant
* **Seeds** ​are the fertilized/mature part of a flowering plant
* **Leaflets** ​are young leaf blades of a plant
* **Roots** ​are the underground structure of a plant used for absorbing nutrients
	+ **Taproot** ​is the main root that helps anchor a plant in soil
	+ **Rootlets** ​are small roots that stem from the taproot and help anchor and absorb nutrients
* **Nodules**​ occur on the roots of the plant that associate with nitrogen bacteria

**Material List**

* Pen/Pencil
* Scissors
* Science Notebook
* (50) Soybean Plant Seeds
* Nature’s Care Organic Potting Soil
* (2) Jiffy® Greenhouses
* (50) Jiffy® Soil Pods
* (3) 6 in. Clay Pots
* Tap water
* 20mL Syringe
* Freezer Set At -20℃
* P-Touch® Labeling Machine
* (2) LED Grow Lights
* Ruler
* Bowl
* (3) Coffee Filters

**Experimental Procedure:**

**Step 1:** Place 25 soybean seeds into a -20℃ freezer for two weeks. Leave 25 soybean seeds at room temperature.

**Step 2:**  Submerge 50 Jiffy® soil pods into a bowl of tap water, remove once hydrated.

**Step 3:**  Place the soil pods into the two Jiffy greenhouses, 25 in each.

**Step 4:** Place the 25 soybean seeds that are frozen into each of the soil pods in one of the Jiffy greenhouses, and place the other 25 soybean seeds that were kept at room temperature in the other soil pods within the second Jiffy® greenhouse.

**Step 5:**  Label the two greenhouses Frozen and Normal, corresponding with the seeds that were placed inside.

**Step 6:**  Print two stickers labeled A through E. Place the sticker inside each greenhouse to label each column.

**Step 7:**  Print two stickers labeled 1 through 5. Place the sticker outside each greenhouse to label each row, causing each and every plant in a soil pod to have a label, such as A5, B3, and D2.

**Step 8:**  Use a syringe to feed each soil pod with 5mLs of water on Mondays and Thursdays.

**Step 9:**  Use a ruler to measure each plant that is growing in inches on Tuesdays and Fridays.

**Step 10:** Record the heights on paper in grids.

**Step 11:** Expose each greenhouse to 6 hours of a grow light, one grow light per greenhouse, every day.

**Step 12:** When the plants grow too tall for the greenhouse, pour potting soil into clay pots with a coffee filter at the bottom, and transplant the plants into the pots. Use 2 pots for the normal seeds, and 1 pot for the frozen seeds. Label each plant by its original label, such as A5, D3, etc., then label the pots normal seeds or frozen seeds, corresponding with the seeds it holds. Continue feeding and measuring them regularly.

**Step 13:** Do this for a duration of 3 weeks.

**Step 14:** Take the transplanted plants out of the pots and observe their root structure, comparing the normal seeds with the frozen ones.

**Step 15:** Observe and take notes on the first and last days of the experiment in a scientific notebook.

**Data and Graphs**



**Early Growth**

|  |  |  |
| --- | --- | --- |
| **Date** | **Normal** | **Frozen** |
| **12/22/2017** | **0 cm** | **0 cm** |
| **12/26/2017** | **5.92 cm** | **3.18 cm** |
| **12/29/2017** | **11.90 cm** | **9.50 cm** |
| **1/2/2018** | **19.25 cm** | **17.80 cm** |
| **1/5/2018** | **22.30 cm** | **19.40 cm** |
| **1/9/2018** | **26.50 cm** | **28.30 cm** |

**Later Growth**

|  |  |  |
| --- | --- | --- |
| **Date** | **Normal** | **Frozen** |
| **1/9/2018** | **3.18 cm** | **7.62 cm** |

**Success/Grow Rates**

Frozen soybean seeds: 4/25

Normal soybean seeds: 8/25

\*The information above states the success rates of possible growth. The chart is the averages of plant growth per group.

**Discussion of Results**

 The data displayed above illustrates the average growth of soybean plants in each greenhouse. The graph and tables show that at the beginning of the soybean plants’ growth, all of the plants were slowly growing. The frozen seeds appeared to have grown slightly less than the room temperature seeds. Towards the middle of the experiment, the frozen soybeans grew to the same height as the normal soybeans, and continued getting closer in height until all of the plants’ growth suddenly slowed. The normal sprouts still grew, but they only grew slightly. The sprouts ended almost equal in height. The difference in their growth was not drastic enough to be considerable. We observed the frozen seeds root structure and compared it to those of the normal root structure, and there was no noticeable difference in their root structure. The taproots and the nodules had no significant differences. Therefore, the growth of the frozen seeds was not significantly different from the room temperature seeds.

**Conclusion**

 According to our hypothesis, the frozen seeds’ growth would be slowed, not stopped, due to the freezing. We were close to being correct. The room temperature seeds grew six sprouts within a few days, compared to the frozen seeds that only grew two. At the end of the experiment, the normal seeds still had more, with eight plants, compared to the four that the frozen ones grew. Though the frozen ones grew less plants, those plants ended up just as large or even larger than the other plants. Our hypothesis was partially correct, because it didn’t slow their growth, it just affected the odds of them growing at all. In the end, the final ratio of frozen plants to normal plants was 4:8, or 1:2. Therefore, there would most likely be twice as many plants from seeds not exposed to extreme cold temperatures. In conclusion, the quality of the soybean plant does not change when the seeds are frozen, but the quantity is going to be lessened when compared to the room temperature seeds.

**Practical Application**

Based on the results of this study, it could be concluded that if farmers use seeds that were exposed to colder than normal temperatures, it will take more seeds to produce the same amount of crops than if the seeds were not exposed to extreme cold. This will increase the cost of growing soybean plants, which will increase the cost to manufacturers who use soybean plants to produce goods. Therefore, it can be expected that the final cost to consumers will also rise.

**Future Expansion**

**Colin:** It would be interesting to grow soybean plants and use liquid vitamins as a food source. Doctors and pharmacists agree that vitamins are important for human growth, but how would vitamins affect the growth of plants? Vitamin B, Vitamin C, and iron (ferrous sulfate) could be used. These three vitamins could be compared to soybean plants being grown with water as a food source. Furthermore, it would be interesting to find out if food produced from these soybeans had more benefits to the humans who consume them.

**Spencer:** We could try growing the soybeans in different climates like moist or humid. We could learn if there are any other things to help increase soybean production.

**Acknowledgments**

**Colin:** I would like to thank our parents for all of the help that they contributed towards materials. I would also like to thank my fifth grade science teacher for supporting me and offering help if needed. Furthermore, I would like to thank my partner for the work he has put into this project. Lastly, I would like to thank my seventh grade science teacher and my extra-curricular science club teacher for their time and support.

**Spencer:** I want to thank my mother, and my partner’s parents. They helped us with the posterboard the most. I also want to thank my science teacher and my science club director for helping provide us with ideas.

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