"Prosperity for the Poor, Health for All"
Improving Stored Seed Viability through Optimal Storage Conditions



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Acknowledgments:

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Personal Background

I was born in Wichita, Kansas and moved to Cedar Rapids, Iowa when I was only three months old. My mother worked as a secretary and my step-father was an engineer. My only connection to farm life was my grandparents who lived on a retired farm. I always loved going to their farm and running around the abandoned pig pen and forlorn chicken coop, pretending I was a real farmer and with real farming responsibilities. Not knowing the first thing about running a farm, that was the closest I ever got to being a regular John Deere.

What I did know was science. Mitosis and cellular respiration just made sense to me, and I loved discussing any and all scientific topics. As my knowledge in the scientific field grew, I learned more about the uses for these concepts. Scientists were finding new vaccinations every day. They were discovering that genetically modified foods could increase yield and that certain genes in animals could help us find new cures for diseases . The fact that science could be used to help people in such significant ways fascinated me. I knew that's what I wanted to do: I wanted to use something I loved, science, to do the one thing I wanted to do most in the world, help people.

When I first heard about the World Food Prize I knew this was the perfect opportunity for me. It would give me a chance to understand how I could put dream into practice and use science to fulfill my goal of helping people. I first heard about the World Food Prize from my friend who had been my school's representative from the previous year. I was instantly intrigued after she explained it to me. Immediately after, I went to the teacher who was in charge of selecting our school's representative, Cindy Garlock. I asked her about it and told her I was interested. This was some time in the month of November. She told me that she would let me know later in the year.

One day in early May I got a pass from my teacher, Mrs. Garlock. When I went to her room she told me that I had been selected as our school's representative for the World Food Prize next year. I think I screamed with joy-I was that excited. My teacher explained the process, about having to write a research paper and attend the conference. I was so excited for all of it. And then she told me about the internship. I had not known that this part even existed. Simply having the chance to apply for an opportunity to go abroad and conduct real research that would actually make a difference was amazing to me.

Attending the World Food Prize conference was one of my best experiences. All I had known before that was classroom science, learning about people and discoveries via textbooks and Power Point presentations. But now I was getting the chance to witness professionals in their fields discuss with other professionals in different fields about the best ways to eradicate poverty and world hunger. It was a meeting of the minds, and I was thrilled to simply observe it. Getting the chance to converse with dignitaries from all over the world was as much exciting as it was inspiring. Here were the people doing what I wanted to do, using their skills and talents to improve the lives of others. It was a room full of superheroes.

There was no doubt in my mind that I would apply for the internship. The knowledge that the average person has about the issues of poverty and hunger is very little. The perception of

these problems is composed from two minute commercials and fleeting statistics that, while shock us, fade from our thoughts by the end of the day. What the majority of people know is that these unfortunate realities of poverty and hunger exist, but we, as a society, are so far detached from these concepts that it is difficult to feel anything but sadness and pity for those who must experience these problems. It is easy to forget, and much harder to do something to resolve it. But I am not the type of person to sit back idly and watch as the commercial depicting the horrors of another land rolls across the screen without wanting to do something to change it. I am not a person who can hear these terrifying and depressing statistics, feel remorse, and then move on with my day. I wanted a chance to experience these problems, so I would know, so I could help.

When I found out that I had been chosen as one of the 2010 Borlaug-Ruan interns, my heart stopped. I had wanted this so badly, and though I thought it was impossible, here I was, holding the manila letter with the golden letterhead telling me it was true. As I read over the letter once, twice, and three times, I knew then that my life would be changed forever.

Background of AVRDC: The World Vegetable Center

The World Vegetable Center is a research institution located in Shanhua, Taiwan. It was founded in 1971 as the Asian Vegetable Research and Development Center due to its initial location. However, as the center expanded in later years, adding sites in other countries, the center was renamed to The World Vegetable Center. Today there are regional branches in Central and West Asia, Africa, and Southeast Asia and Pacific.

The World Vegetable Center

Genetic Resources and Seed Unit

The center focuses much of its research on indigenous plants,though, it has a great many other species. AVRDC works to eradicate hunger and poverty in developing countries through providing the tools and knowledge to increase yields and provide healthier vegetables. The center is a public institution so any other research center can request seeds, and all data and findings are open to public viewing. Often times, an exchange is performed when another center requests seeds. This allows AVRDC to collaborate with other research centers and scientists. The center operates under the Convention on Biological Diversity and the International Treaty on Genetic Resources for Food and Agriculture which facilitates the sharing of resources such as germplasm between centers. The policies guarantee that if researchers at AVRDC make a notable discovery, they must share this information with the center that originally provided the resources vital in making the discovery.

The Word Vegetable Center is a non-profit independent institution. Although they receive some government funding, it is not controlled by any government. Both private foundations and various international governments provide funds for the non-profit research center. The annual budget is about $18 million a year total for all the locations.

Working at the headquarters of AVRDC, I was able to see the center in its entirety. The center has several different departments including Bacteriology, Biotechnology, Molecular Breeding, and Plant Physiology, Crop and Ecosystem Management, Entomology, Genetic Resources and Seed, International Cooperation, Mycology, Nutrition, and Virology. Since my project dealt with seed viability, I spent the majority of my time working in the Genetic Resources and Seed Unit (GRSU), although I got the chance to spend time in other units as well. I harvested and inoculated peppers with the staff from the Breeding Unit, ran gels using the method of gel electrophoresis in the Biotechnology Unit, and ran PCRs (Polymerase Chain Reactions) in the Molecular Breeding Unit.

I. Introduction

Cucurbitaceae Family: Characteristics and Importance

Cucurbitaceae is considered to be one of the most diverse families of plants in the kingdom. Plants within the family include such vegetables as gourds, melons, squash, and cucumbers. This family is known to be frost sensitive and found primarily in sub tropical and tropical regions. The Cucurbitaceae family is known for their “climbing tendrils.” Cucurbitaceae is often referred to by a shortened name, Cucurbits. The four species of Cucurbits used in this experiment were *Cucumis sativus, Cucurbita moschata, Momordica charaintia, Lagenaria siceraria.*

The seeds of Cucurbits are generally flat. Inside the seed is an embryo, the perisperm, which is a layer of tissue that surrounds and provides nourishment to the embryo, and little or no endosperm. The size, shape, and color of the seeds are vastly different among each species, and within as well.

The seedlings of Cucurbits are considered to be epigean, meaning that during germination, the tips of the cotyledons initially are inverted, but later become erect. The cotyledons are something like the plants first leaves. If a species has one cotyledon, it is classified as a monocotyledonous or “monocot.” If a species has two cotyledons, it is classified as a dicotyledonous or “dicot.” All four species used in this experiment are classified as dicots. The cotyledons are similar to true leaves in that they carry out the process of photosynthesis.

However, cotyledons are developmentally different from true seeds. They develop during embryogenesis, so they are already present within the seed. True leaves develop after germination has occurred. The two cotyledons take up much of the room inside the seed.

When the Cucurbit seed begins to germinate, the hypocotyl will straighten and the seed coat will be extricated by a structure called a peg on the hypocotyl. The peg's function is to open the seed coat, thus allowing for the emergence of the cotyledons. The shape of Cucurbits' cotyledons is described as oblong.

The primary root of Cucurbits is said to be very strong, able to infiltrate one to two meters of soil. Cucurbits have many secondary roots that are near the surface of the soil. The cortex of the primary root is responsible for the secondary roots' development. Some species have large storage roots that assist the plant in surviving long droughts.

Cucurbits have many uses in many different fields. The fruit of the plants can be eaten, such as melons and cucumbers. The juice from the fruits can be fermented as is done in Japan. Even the roots and leaves of the plants have their uses. The seeds from Cucurbits are an important part of the diet in Africa. The nutritional value of Cucurbits makes them an ideal food source for the developing world. The fruit contains a high amount of Vitamin B, Vitamin A, and calcium, and the shoots of the plant are a good source of calcium, phosphorus, and iron. Gourds can be used to make storage containers, kitchenware, smoking pipes, instruments, etc. Cucurbits also have uses in make-up and pharmaceuticals. For example, the seeds of winter squash have been proven to prevent kidney stones and the flowers have been shown to reduce jaundice. Over the past years, the land devoted to just melon has increased by 35% increasing yields by 60%, and the land for cucumbers has increased by 25% increasing yields to 38%. The same is happening for many other species of Cucurbits as their importance seems to be growing. Given this recent rise in their production, it is clear that not only are people demanding more of Cucurbits, but there is an increasing dependence on their production.

Characteristics and Information Concerning the species of *Cucumis sativus, Cucurbita moschata, Lagenaria siceraria,* and *Momordica charantia*

Cucumis sativus:

Cucumis sativus, its common name being cucumber, originated in southern Asia, but its cultivation has obviously expanded to all over the world. It is classified as an annual and a "climber." For best growing results, the *Cucumis sativus* species needs full light and consistent moisture. The plant's pollination type is open pollination and usually begins bearing 50-60 days after being planted. The average height of the species is between 6 to 8 feet. Because it is sensitive to cold and harsh weather conditions, it is a species that requires slightly more care than others.

Cucurbita moschata:

Cucurbita moschata, its common name being winter squash, is a plant that requires full sun and a medium amount of water to keep it moist but prevent drowning. The plant can grow between 12 to 18 inches. The type of pollination is open pollination. The seedling can grow in acidic or neutral soil. The plant reaches maturity in 111 to 120 days. It is a vining plant.

Lagenaria siceraria:

The common name of *Lagenaria siceraria* is bottle gourd. It is one of the first domesticated plants in history. The plant is indigenous to Africa, but reached Asia in the last 10,000 years. It can grow in harsh climates such as rocky soil and little light or water. *Lagenaria siceraria* can get up to 16 feet tall. It can be a prostrate plant or also a climber.

Momordica charantia:

The common name for *Momordica charantia* is bitter melon. It is a vining plant and is known, and used all around the world, for its medicinal properties. There have been close ties to this particular species reducing the symptoms of HIV and certain cancers. This plant needs full sun/or light shade and moist soil.

Seed Viability: Importance and Testing Method

Germination tests are used to determine the viability of seeds. Seed viability is a measure of how alive the seeds are and if they could develop into healthy organisms capable of reproduction. Germination testing helps to measure the field planting value of the seed. The seeds must be germinated under optimal conditions for accurate results.

It is necessary to test seed viability to know how long seeds can be stored. It is the goal of many gene banks to increase the length of storage, without sacrificing viability. Seed storage is necessary to keep seeds for long periods of time so they are accessible at a later date. To know the type and length of storage seeds can be stored at is vital to the success of gene banks. Seed viability should be tested at the beginning of storage and then at regular intervals throughout storage.

Storage Conditions

The three types of storage conditions used in this experiment were short term, medium term, and long term. Short term storage is kept at 15 degrees Celsius and seeds stored here are just temporary storage. Medium term storage is at -5 degrees Celsius. The seeds stored in medium term storage are estimated to last 20-50 years. Long term storage is kept at -15 degrees Celsius and the seeds stored here are estimated to last between 50-100 years.

Temperature plays a large role in seed germination. If the temperature is too high or too cold, the seeds will not germinate. Moisture is another major determinate of germination. If the seeds are not given enough water, they will remain dormant, however if they are given too much water, the seed will rot before it can develop. The seeds are stored at lower humidity and temperatures to prevent the seeds from beginning germination while still in storage.

Types of Germination

There are four categories seeds can fall into with the germination tests: normal, abnormal, dead, and hard.

There are three types of <u>normal</u> seeds:

1. **Intact**: Intact seeds have a developed root system with a long primary root covered in fine root hairs and ending with a defined tip, and numerous secondary roots. There is a straight and long hypocotyl. The seedling will have a specific number of cotyledons, depending on the species, and one or two primary leaves, depending on the species. An intact seed will also have a terminal bud, which is the shoot apex enveloped by differentiated leaves.

(See Appendix A)

2. **Seedlings with Slight Defects**: The following is a list of defects that would be classified as slight:
    - Slight damage or growth retardation in the primary root
    - Defective primary root but well developed secondary roots
    - Hypocotyl with limited damage
    - Cotyledons with limited damage (follow the 50% rule*)
    - Only one cotyledon instead of two in a dicotyledon.
    - Three cotyledons instead of two
    - Primary leaves with limited damage
    - Only one primary leaf
    - Three primary leaves instead of two

*50% rule: If half or more of the tissue is left functioning, it is considered slight damage.

3. **Seedlings with Secondary Infection:** Seedlings that have all the essential structures and are classified as normal but have been decayed by bacteria or fungi, if it is clear that the seed was not the source of infection.

Abnormal Seeds: If the seedling has one or more of these defects then it is classified as abnormal.

- **Primary root** is stunted, retarded, missing, broken decayed by primary infection, or glassy.
- **Hypocotyl** is short and thick, missing, constricted, glassy, or decayed as a result of a primary infection.
- **Cotyledons/Primary leave** are deformed, missing, discolored, or decayed due to primary infection. Apply the 50% rule
- **Terminal Bud** is deformed, damaged, missing, or decayed due to primary damage.

(See Appendix B)

Dead Seeds:

Dead seeds are soft, moldy, discolored, and show no signs of seed development.
(See Appendix C)

Hard Seeds:

Hard seeds are ones that have not germinated at the end of the trial, but the coat still remains hard. The seed is therefore considered in a state of dormancy. A variety of methods can be used to break dormancy, such as prechilling, preheating, and use of Gibberellic acid.

II. Abstract

Seed viability is extremely important when it is necessary to store seeds for a long period of time. Discovering which methods sustain seed viability with increased storage is vital to prolonging the life of seeds. It is a combination of both duration and temperature that affects seed viability, so it is therefore important to regulate these two factors to find the optimal conditions for retaining seed viability in storage. If this is achieved, then it will be possible to keep seeds and utilize them longer than what is normally possible without storage, without the seeds losing viability.

The goal of this specific experiment is to look at how viability is affected by varying storage conditions for four species from the Cucurbitaceae family: *Cucumis sativus, Cucurbita moschata, Lagenaria siceraria,* and *Momordica charaintia.* The effects will tell us if it is possible to retain viability with prolonged storage and which particular storage combination is most effective.

The hypotheses for this experiment are as followed:

1) With increased storage time, the general viability for the four species will decrease.
2) The seeds in long term storage will have greater viability than the short and medium term because the colder temperatures will prevent the loss of viability and keep the seed longer.

Quantitative methods were used to collect the primary data for this experiment. Secondary data was gathered from publications and the International Seed Testing Association (ISTA). To test for seed viability we used typical germination tests. Due to the size of the seeds, the "between the paper" (BP) method was used. All species and types were tested under the same method to maintain the accuracy of the results. The experimental variable was the type and the duration of storage. There were three different types of storage: short term (15°C), medium term (5°C), and long term (-15°C). There were three different durations of storage: two weeks, four weeks, and eight weeks. There were four different types of species and each species had three different accessions. There were three replications of each accession. In total, 324 data sets were obtained from this experiment. The data was collected and analyzed using the appropriate techniques. Graphs and charts were used to represent and display the collected data.

The results showed:

1) Both *Cucumis sativus* and *Lagenaria siceraria* are extremely viable regardless of storage conditions.
2) *Cucurbita moschata* have a high percentage of abnormal development.
3) Based off the results, the longer seeds are stored, the better the viability.

   And most importantly:

4) *Momordica charantia* die in long term storage

The study shows the effects of storage conditions on four species of Cucurbitaceae crops. According to the results, with increased storage, the viability increases. However, based off the findings of other research on seed viability, this is not accurate. The procedure would have to be performed again to validate the results. The main discovery is the fact that in long term storage,

the seeds of *Momordica charantia* die. The reason for the complete loss of viability with long term storage is unknown. Further research could be done to discover the reasons for the loss of viability.

III. Materials and Methodology

The materials used in this germination experiment include the four species of Cucubit crops, three accessions of each, with three replications of each accession. For *Cucumis sativus* accessions TOT1180, TOT1403, and TOT1406 were used. For *Cucurbita moschata* accessions TOT1185, TOT6252, and TOT7875 were used. The accessions TOT7335-A, TOT7334-A, and TOT7335-D were used for *Lagenaria siceraria*. For *Momordica charantia* accessions TOT6236, TOT6557, and TOT7875 were used. All replications of each accession for all four species were exposed to three different storage conditions for three different durations. For the species of Momordica and Cucurbita, twenty-five seeds were used for each replication. Given the varying conditions of the experiment, 675 seeds per accession of the species Momordica and Cucurbita were needed. For the species Lagenaria and Cucumis, fifty seeds were used for each replication, coming out to 1,350 seeds being used for the entire experiment.

Kitchen paper towels were used as the germination paper. Thin, clear plastic sheets were used as the setting for the kitchen towels. A forceps was used to place the seeds on the paper towels, as well as to remove the germinated seeds. A solution of 70% alcohol was used to sterilize the work surface and the forceps. Distilled water was used on the kitchen towels, as well as in the buckets the replications were placed into. Metal racks were used to hold the replications and the racks were placed into buckets. To label the replications, small plastic labels were used. The procedure (listed below) used for this experiment is the one outlined by the International Seed Testing Association (ISTA). The testing method applied for seed germination of the crops will be the BP method (between the paper), in a paper roll.

Storage:

The seeds first had to be stored for the directed times. There were three replications of each accession (TOT1180, TOT1403, and TOT1406) of the *Cucumis sativus species* in short term storage for two weeks. Three replications of each accession of the *Cucumis sativus* species were stored in short term storage for four weeks. Three replications of each accession of the *Cucumis sativus* species were stored in short term storage for eight weeks. This procedure was repeated for three replications of each accession (TOT1180, TOT1403, and TOT1406) of the *Cucumis sativus* species for medium and long term storage for durations of two, four, and eight weeks.

There were three replications of fifty seeds of each accession (TOT7335-A, TOT7334-A, and TOT7335-D) *of Lagenaria siceraria* in short term storage for two weeks. Three replications of fifty seeds of each accession *of Lagenaria siceraria* were stored in short term storage for four weeks. Three replications of fifty seeds of each accession of *Lagenaria siceraria* were stored in short term storage for eight weeks. This procedure was repeated for three replications of fifty seeds of each accession (TOT7335-A, TOT7334-A, and TOT7335-D) for medium and long term storage for durations of two, four, and eight weeks.

There were three replications of twenty-five seeds of each accession (TOT1185, TOT6252, and TOT7875) of *Cucurbita moschata* in short term storage for two weeks. Three

replications of twenty-five seeds of each accession of *Cucurbita moschata* were stored in short term storage for four weeks. Three replications of twenty-five seeds of each accession of *Cucurbita moschata* were stored in short term storage for eight weeks. Repeat this procedure for three replications of twenty-five seeds of each accession (TOT1185, TOT6252, and TOT7875) of *Cucurbita moschata* for medium and long term storage for durations of two, four, and eight weeks.

There were three replications of twenty-five seeds of each accession (TOT6236, TOT6557, and TOT7875) of *Momordica charantia* in short term storage for two weeks. Three replications of twenty-five seeds of each accession of *Momordica charantia* were stored in short term storage for two weeks. Three replications of twenty-five seeds of each accession of *Momordica charantia* were stored in short term storage for two weeks. This procedure was repeated with three replications of twenty-five seeds of each accession (TOT6236, TOT6557, and TOT7875) of *Momordica charantia* for medium and long term storage for durations of two, four, and eight weeks.

Storage Area and Coolers

Inside Cooler

Setting:

A 100% alcohol solution was diluted to 70% mixing 70 ml. of the alcohol solution with 30 ml. of distilled water. Using the 70% solution, the work area and the forceps were sanitized. A clear, thin sheet of plastic was placed on the work table. A small water-proof label was used to mark the species, the accession number, the replication number, and the type and duration of the storage. The label was placed on the bottom corner of the plastic. About two sheets of kitchen paper towels were placed over the plastic and on top of the label. The towels were wetted with distilled water.

The seeds were obtained from storage in the coolers. The necessary bag of seeds was opened and the seeds were evenly distributed on the paper towel using the forceps. For

Lagenaria siceraria and *Cucumis sativus*, the arrangement of rows of 5x10 worked the best. For *Momordica charantia* and *Cucurbita moschata*, the arrangement of rows of 5x5 worked the best.

The seeds were then covered with a layer of paper towels and wetted with distilled water like the first time. The plastic sheet containing the paper towels and the seeds was rolled up into a tube in a way that the label could be viewed. The plastic tube of the replication was placed in a stand. When the stand was filled with replications, the stand was placed into a tub. The tub was filled with enough distilled water (about an inch) for the bottom of the paper towels of the replications to touch the water. Since there were three replications for each accession of each species, one of each of the three replications was placed in a separate tub to be put into different incubators. This was done to maintain the accuracy of the results by accounting for machine error. It was necessary to account for the effects, if any, the incubators had on the germination rates.

Placement of *Cucumis Sativus* seeds

All of the replications were placed in incubators. The temperature of the incubator was set for 30 degrees Celsius and light for 8 hours, and 20 degrees Celsius and no light for 16 hours. The replications all received an adequate amount of water.

Counting:

The seeds were counted on the days directed by ISTA. The chart for counting is shown below. It depicts the number of days after setting the counts occurred:

Species	Ct. 1	Ct. 2	Ct. 3	Ct. 4
Cucumis sativus	4 Days	8 days	13 Days	18 Days
Cucurbita moschata	4 Days	8 Days	18 Days	25 Days
Lagenaria siceraria	4 Days	14 Days	20 Days	26 Days
Momordica charantia	4 Days	14 Days	22 Days	28 Days

Before the seeds were counted, the work surface and forceps were again sterilized with the 70 % alcohol solution. A small container of the 70% alcohol solution was used to sterilize the forceps throughout the counting process. This was done in the event that an infected seed had to be removed. Sterilizing the forceps after removing an infected seed was important to prevent secondary infection to other seedlings. A data table to record the crop, method (BP), species, storage conditions, replication number, accession number, date, and the germination results was used to record the findings.

The tubs of replications were removed from the incubators and the plastic tube was unrolled. The paper towel was removed. The seeds were counted and recorded in the spots for normal, abnormal, dead, and hard seeds. The type of germination was classified by the guidelines defined in the introduction section of the paper. After the first counting, the number of seeds left that were not yet germinated was also recorded. For the first two countings it was difficult to tell whether seeds could be classified as hard, so the recordings for that category were not as high for the first two countings.

Normally germinated *Cucumis sativus* seedling

For some of the countings, there were a number of seeds that had become infected. When the seeds had become infected, they had to be removed to prevent them from infecting other seeds. The surrounding area of the paper towel also had to be removed to prevent contamination. On some occasions it became necessary to remove simply the healthy seeds because so many had become infected. In an event like this, the above setting procedure was followed to relocate the few healthy seeds onto another setting.

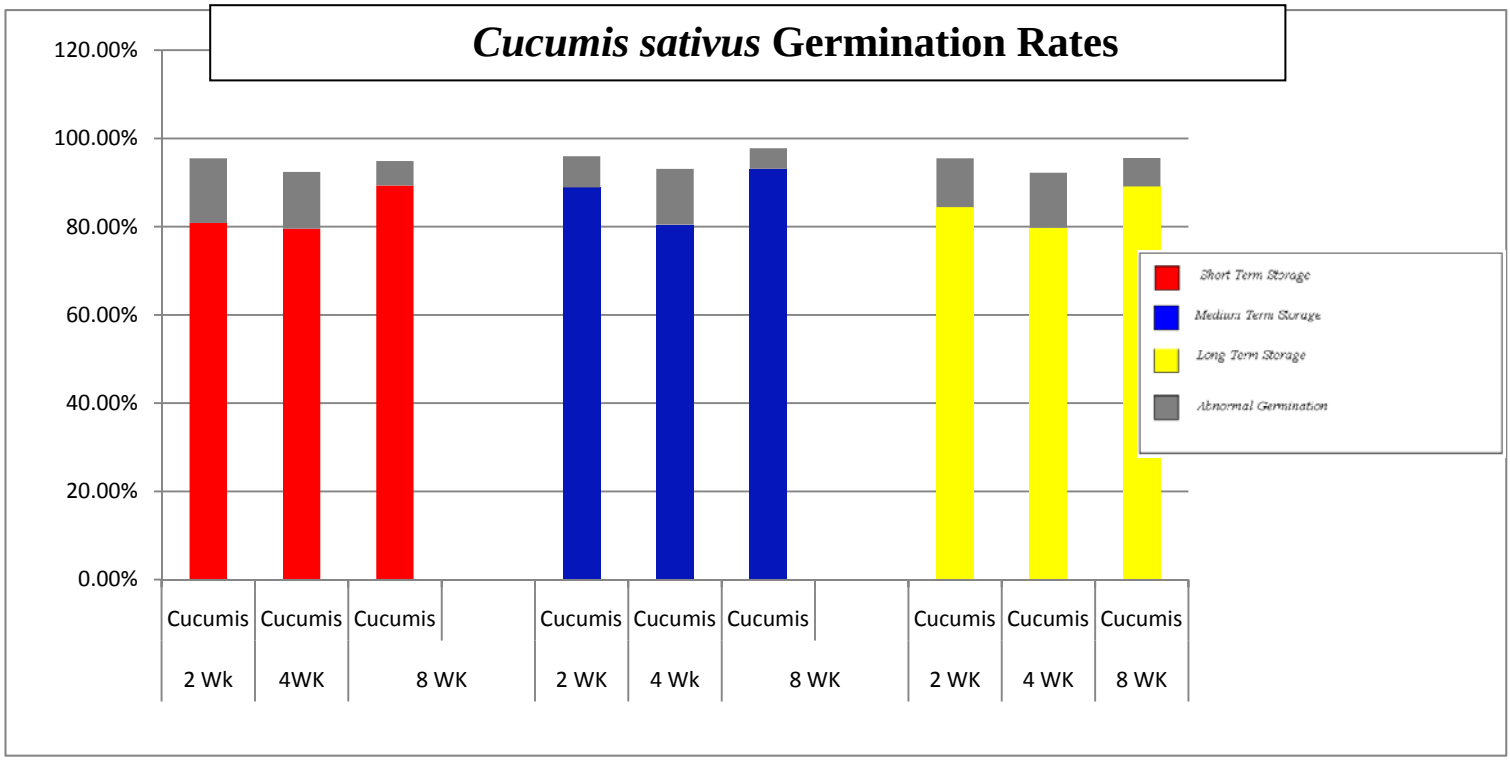
When the counting was complete, the paper towel was replaced over the seeds that had not germinated, and the replication was rolled up and replaced in the rack in the tub. The tubs were then replaced to their respective incubators until the next counting day designated by ISTA.

IV. Results

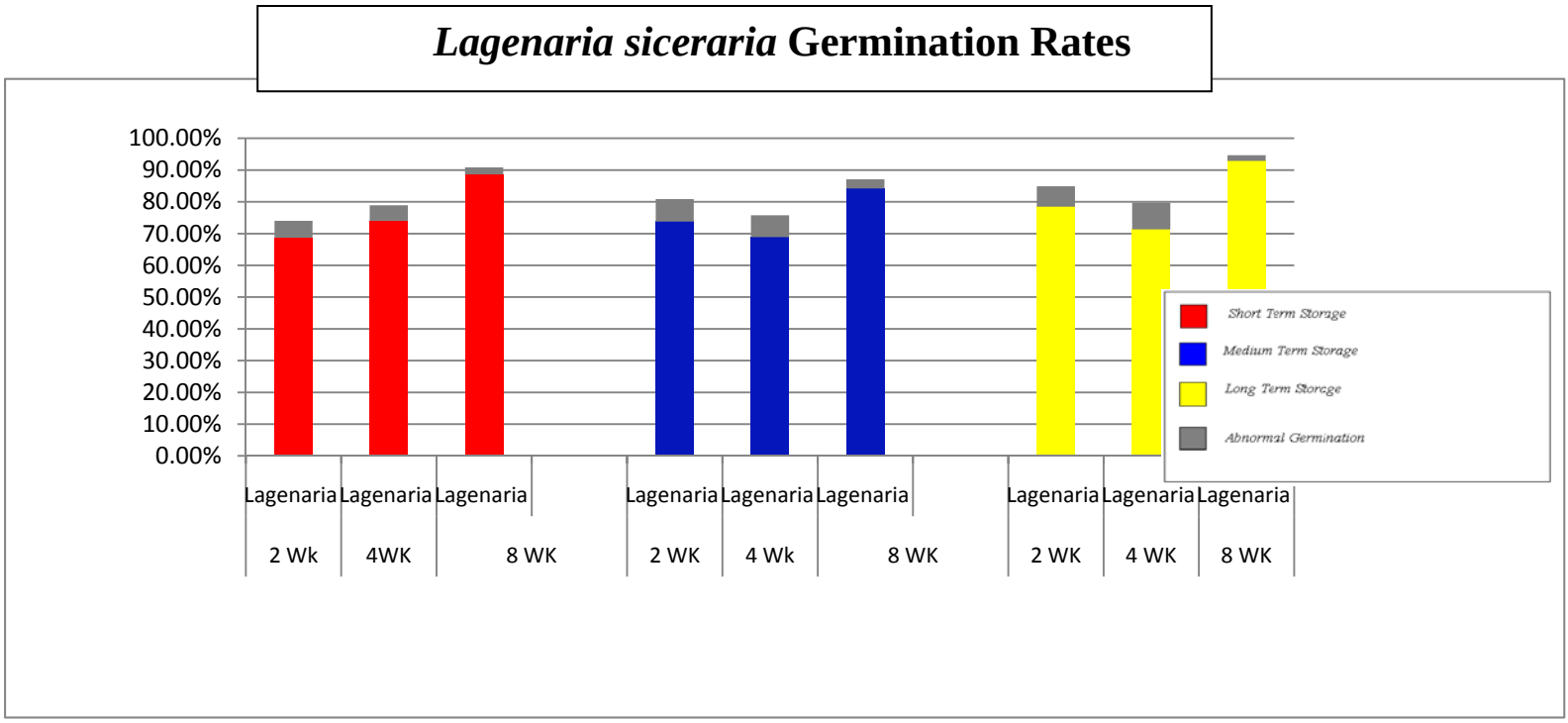
The results from the data collected are illustrated by the following graphs.

Note: The abnormal germination rate was added to the graph because it is still possible for abnormal germinated seeds to produce fruit:

The data the graphs were generated from is listed in Appendix D-G

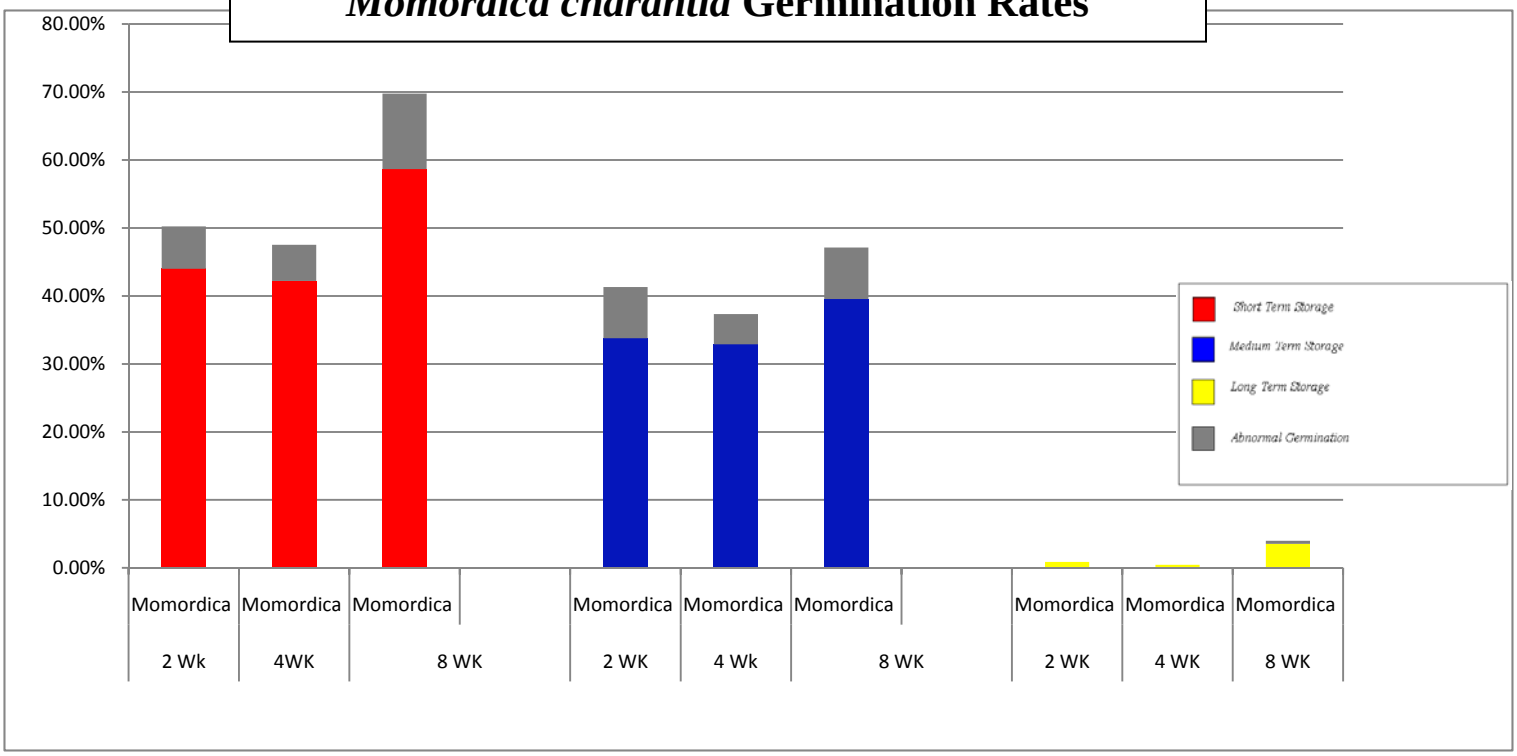


This graph shows effects of the type of storage on the seed viability of the *Cucumis sativus* species. There are only minor differences between the germination rates with different storage durations in varying storage types.



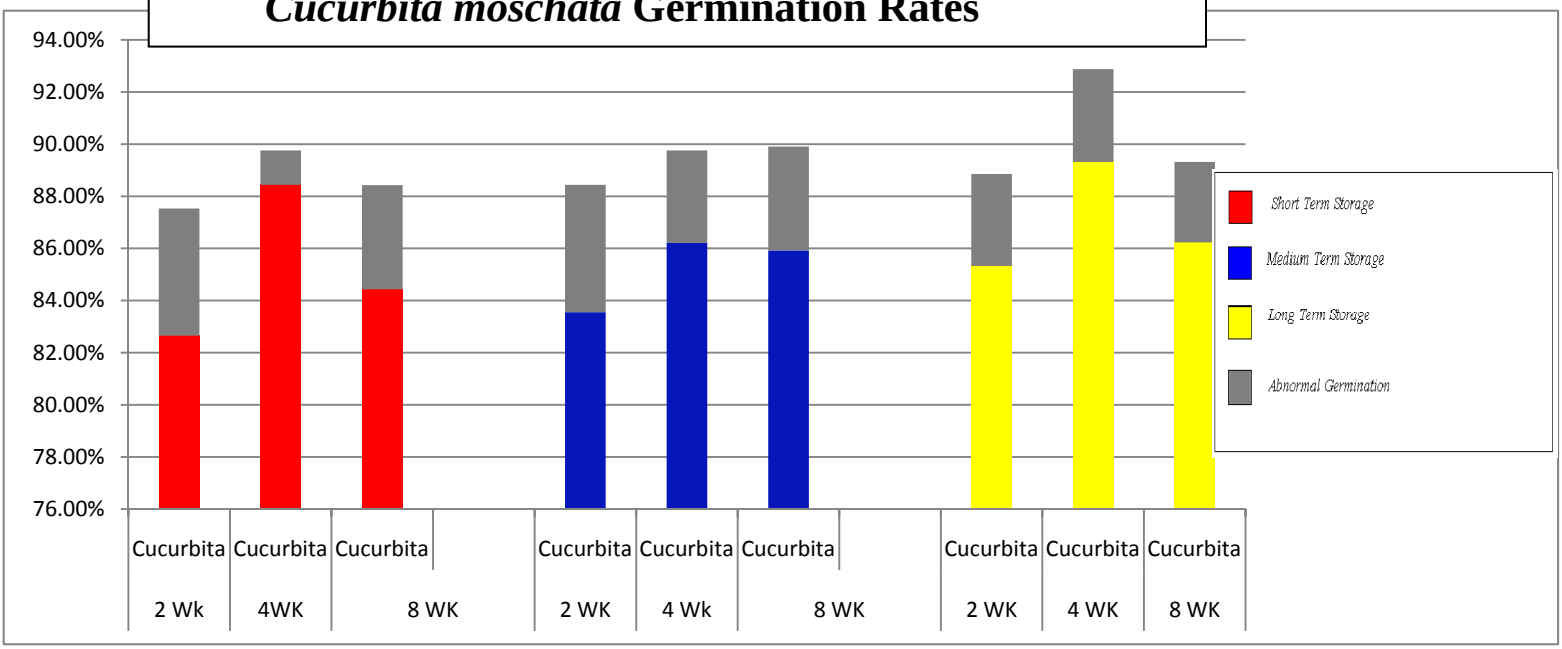
This graph shows the effects of the type of storage on the seed viability of the *Lagenaria siceraria* species. There are only minor differences between the germination rates with different storage durations in varying storage types.

Momordica charantia Germination Rates



This graph shows the effects of the type of storage on the seed viability of the *Momordica charantia* species. The viability for the seeds stored in medium term storage is lower than that of short term storage. In long term storage, the viability is near zero.

Cucurbita moschata Germination Rates



This graph shows the effects of the type of storage on the seed viability of the *Cucurbita moschata* species. There are only minor differences between the germination rates with different storage durations in varying storage types.

V. Discussion

Based off the results, a few conclusions can be made:

1) Both *Cucumis sativus* and *Lagenaria siceraria* are extremely viable regardless of storage conditions.
2) *Cucurbita moschata* have a high percentage of abnormal development.
3) Based off the results, the longer seeds are stored, the better the viability.

And most importantly:

4) *Momordica charantia* die in long term storage.

The first conclusion gives hope to the ability of retaining seed viability through the method of storing. Because the results showed that the viability of *Cucumis sativus* and *Lagenaria siceraria* was not majorly affected by storage, this means that it is possible to prolong the life of seeds simply by storing. This could be a beneficial finding for researchers working on a project were it is necessary to keep seeds for a longer period of time.

Conclusion two has little significance in terms of information on the effects of storage conditions. It is however interesting to note this unique finding. Perhaps storage could have affected the plant maturation in some way that caused an increase percent in the number of seeds that germinated abnormally. More research could be done to see whether it was in fact the storage conditions which affected the germination type, or if it is simply that particular species that has a high amount of abnormal germination.

The third conclusion states that the longer the seeds are stored, the better the viability. This contradicts with other research done on seed viability and storage. According to secondary research, with increased storage, the viability should decrease. Given that the results were not the ones predicted, the test would need to be repeated to check for accuracy before any conclusion can be drawn.

Conclusion four is the most important one from this experiment. In long term storage, the species of *Momordica charantia* die. The seeds lose all viability and become of no use after only two weeks spent in long term storage. This finding makes sense given the fact that Cucurbitaceae crops are frost sensitive. Perhaps this specific species is more prone to frost conditions, like the conditions in long term storage. However, there has been no documented record of the reasons for the death of *Momordica charantia* in long term storage.

Points of error could have been during the storing, setting, and counting processes of the method. The seeds harvested from any of the fruit could have sustained a primary infection that killed the seed and possibly infected other seeds around it through secondary infections. Another chance for infection could have come during the setting process. The area where the seeds were prepared may not have been disinfected well enough, resulting in contamination. Some seeds were also lost when they fell out of the plastic roll into the tub of water. These seeds could not have been counted, possibly altering the results.

Based on my findings, I would recommend that the tests be repeated for accuracy. I would also suggest that more work be done on figuring out the reasons for *Momordica charantia* being intolerable of long term storage. Seed viability is vital to the continuation of discoveries, and an adequate way of storing seeds for long periods of time will prove beneficial to later work involving seeds and germplasm.

Personal Reflections

We were all told that this experience would change our life. By the former interns, by Lisa Fleming, and deep down, we knew it, too. We knew that we could not stay away from our family, our friends, our life as we knew it for two months, and come back the same. But what we weren't told, what we didn't know, was when that change would happen. For me, when I arrived in Taiwan, I guess I just expected to feel like a completely different person. Like the change would happen, just like that. And when it didn't, I sort of panicked. I thought, "What have I gotten myself into? Two months away from everything I care about. Two months in isolation? Good going Tamara!" I would just have to get through these two months and deal with it. I didn't think that the change would happen.

All of that was in the first week. It was difficult being the youngest person on campus. I wasn't with a host family, so when I left work, I went home to an empty room. I didn't have much to do at nights, and there was no one my age to talk to. I had never been in this situation before and I felt terribly lonely. It's funny how people can adapt so quickly. I was looking at this situation all wrong.

Me in front of the Confucius Temple

Since there was no one around my age, I decided to make friends with the older people, the researchers who lived on campus. And what I found was that I really enjoyed being able to converse with people who have seen so much and done so many interesting things. This internship was about learning, and what better people to learn from than those who are doing the things I wanted to do? I soon made friends with people from all departments, and they were all so welcoming and encouraged my questions and curiosity.

I got the opportunity to go all over the island during my time in Taiwan. I was able to spend a weekend in Taipei, the capital, to experience Taiwan city life. I stayed with my friend from work and her family. They were extremely hospitable and took me all over the city to the night markets, museums, and Taipei 101, the second tallest building in the world.

Many of my weekends were spent with my supervisor and his wife, Andreas and Ingrid Ebert. They took me on mini-trips to the mountains, temples, and mango markets. We'd regularly stop somewhere to have a picnic during lunch. Ingrid even taught me how to make jam during my time there. Andreas and Ingrid treated me like a daughter and made sure my stay in Taiwan was enjoyable.

I consider myself very lucky to have gotten the chance to meet those individuals in Taiwan. Every person made me feel so welcome in a place that was so strangely new to me. I had so many questions, and wanted to learn as much as possible. Through the great patience of my new friends I was able to pick up some Chinese. The first thing I learned in Chinese was "I want to go swimming," so I could ask the guard at the gate for the key to the pool. Although my pronunciation was often terrible, the Taiwanese who I tested my Chinese on were always excited and grateful to hear me making an attempt to embrace their culture. They taught me so much, about Taiwan, the language of Chinese, and forming relationships between two different individuals. Although I could not always express the exact ideas that I wanted, communication

wasn't really ever an issue. We are all more alike than different, and the simple, yet deep feeling of friendship was always conveyed and understood.

But what I noticed most after some time spent in Taiwan, was that we can't sit around, just expecting something to change our lives. Our lives are changed by us doing, not by just waiting. By completely embracing this experience, the culture, and the people, I started taking actions to get the most from my time in Taiwan. And once I stopped worrying about whether this experience would change my life, I realized that's exactly what it had done.

The World Food Prize Foundation focuses on food scarcity and poverty. I know that while communicating with the other interns, they all talked about leaving their campus, going into the city and seeing the streets lined with the impoverished masses. They talked about how Earth-shattering it was to see such despair in such an affluent city.

But in Taiwan, I didn't see that. There weren't people laying on the sidewalks in Shanhua, and there were very few in Tainan. I never traveled to more rural areas, and living on campus with such nice accommodations, I don't think I really saw poverty. I have been told that Taiwan hides their poverty, and if that's true, they do a very good job of it. But Taiwan is a small island. It's not overpopulated, nor very expensive to live there. While staying there, you don't get the feeling of real, true poverty.

At first, I was somewhat disappointed by this, that I didn't get to see poverty firsthand. I know that seems strange, but living in America, in Iowa, a state that has a relatively low poverty rate, I thought that maybe finally I would know what poverty was, or at least get a better sense of it. I wanted to put some emotion behind the word. A person can only be sympathetic without feeling the emotion. I wanted to empathetic, to know what it was they felt. Missing out on that chance was a bit upsetting.

But then I realized something. You don't have to experience poverty to know that you want to work to help end it. It's true, it helps to know the emotion behind poverty to better relate with others who have experienced it, but it's not necessary. I don't have to have lived without shelter to know it's terrible. I don't have to have gone without water to know I want to help those who have. I don't have to have gone hungry to know it's something that no one should have to experience. I don't have to have experienced poverty to know it's something I want to work to end.

My new friend, Jenny, from the Christian Mountain Children's home.

On campus, working in the labs, doing my experiment, it was sometimes easy to forget why a place like AVRDC exists. This research center was created for a reason, and it wasn't just to do research. It's for development, too, and to me, that's the most important part. What good is any of this research if all you do is put it on a shelf? The discoveries from the research should be used to make lives better.

While I loved working in the lab, I felt I would be missing out on the complete experience if I had not had a chance to interact with the people from Taiwan, the ones outside my research center. I was fortunate enough to befriend a lady named Helen who was in charge of

the cafeteria. I had asked her about volunteer opportunities in the city that I could do on the weekends. She gave me a couple of options and I decided on the Christian Mountain Children's Home, which was an orphanage located in the mountains of Kaohsiung city. We made the drive down to the city so I could help out at the orphanage.

When we got there, we were greeted by a gentleman who showed us around the campus and told us the history behind the orphanage. It was first started by a pastor and his wife who took in so many children that they needed to move out of the city and into the surrounding mountainside. They took a couple tents from the church and lived in them for years while they raised and taught their children. Eventually, they had collected enough money to construct a few buildings for the children and the parents. Over the years the orphanage has increased in size of campus and number of children. It is good to know that there is a place like the orphanage where abandoned children have a home.

After the tour I got a chance to interact with the children there. I played dolls with two adorable little girls and partook in a game of tag with a small group of children. At lunch time, I helped the children set the table. When we had finished setting the table, the sweetest little girl approached me. She wanted to try her English on me. She managed to say a few words with my assistance. After our English lesson, she said thank you and gave me a great hug, looking up at me.

The way that little girl looked at me, instantly stopped all thoughts before that. She looked at me in such complete awe, in utter amazement. She looked at me as though I was powerful, as though I was capable of making changes, of making a difference. And with that look, I fell completely in love with her in that very instant. It didn't matter that I couldn't speak her language, and she couldn't speak mine. Our communication was much deeper than that, and we succeeded in becoming friends without speaking. Every time she shot me that adorable, playful smile, I fell more and more in love with her. I spent the rest of the day playing with her and her friends. Pretty soon, we had to leave and start heading back to campus. As I said my good-byes to her and gave her a big hug, it was in that moment that I realized she had given me the life changing moment I had been waiting for this whole trip. I realized something very vital to not only the experience of the internship, but also for my life in general. What I realized is that I do not have to save the world to make a difference.

Knowing the way things are; the despair, the hunger, the impoverishment of the developing world, it is easy to feel overwhelmed. After observing the dignitaries at the World Food Prize conference earlier that year, I had become incredibly inspired. I wanted to save the world too. Because of this, I had gone into this experience thinking that it would lead me in the direction I needed to indeed save the world.

But that's not the goal I should have been after. Putting the weight of the world on you will do no good. Thinking you alone must deliver everyone from poverty and hunger is a daunting task; it will inundate you with the responsibility. What a person should strive to achieve is doing what they can, the best they can, to help as many as they can. The problems of hunger and poverty cannot be resolved by one person, rather it takes the cooperation of many, from a variety of different fields. It is one thing to have the science to solve a problem, but what good does the information do without the knowledge of how to apply it? What good is the information without the tools to implement it? What good is the information without the policies to allow it? It is a team effort to end poverty and fight hunger, this internship has shown me that. I cannot simply ignore what I have learned about the struggles of the developing world. There are problems and there is suffering and through collaboration they can be solved. So I will do my

best and I will work my hardest to do my part, because I now know that I don't need to save the world to make a difference within it.

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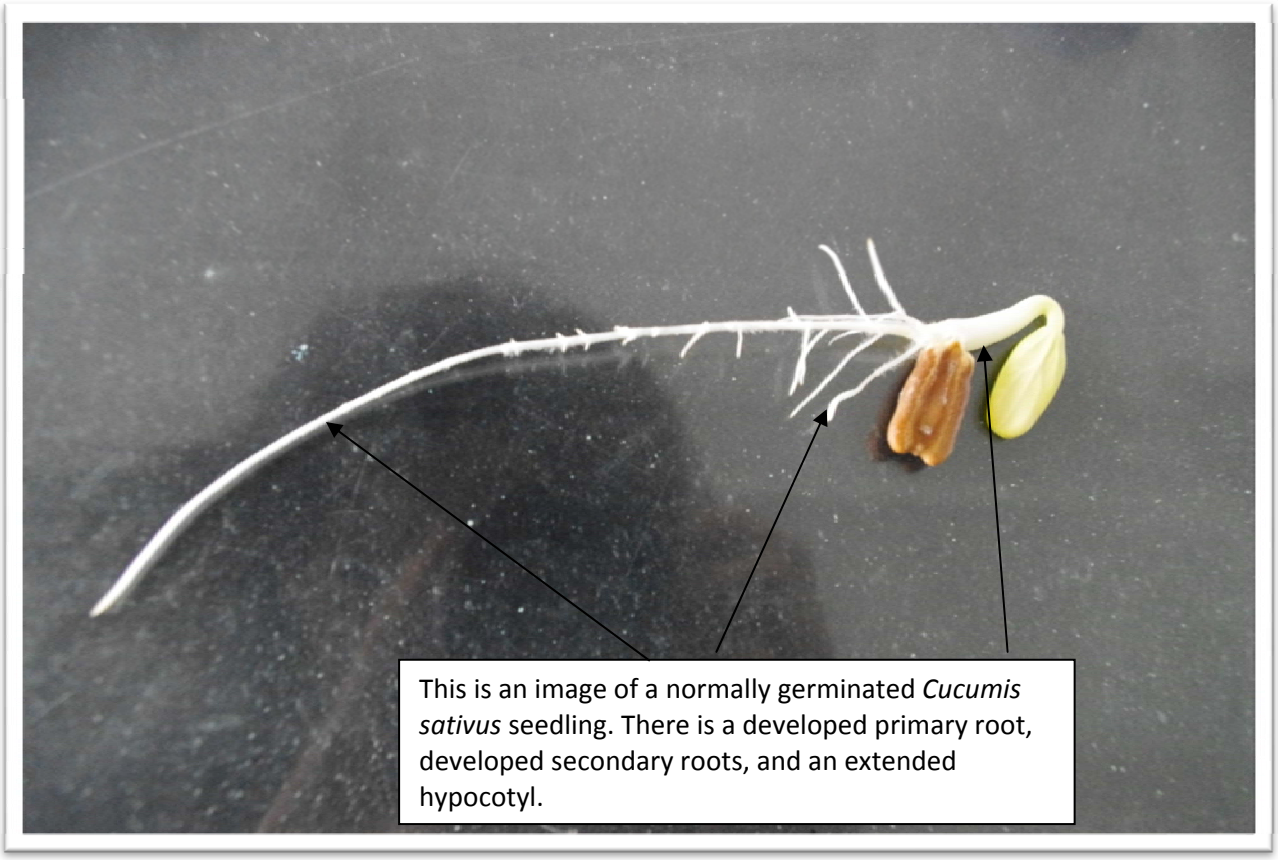
Appendix A

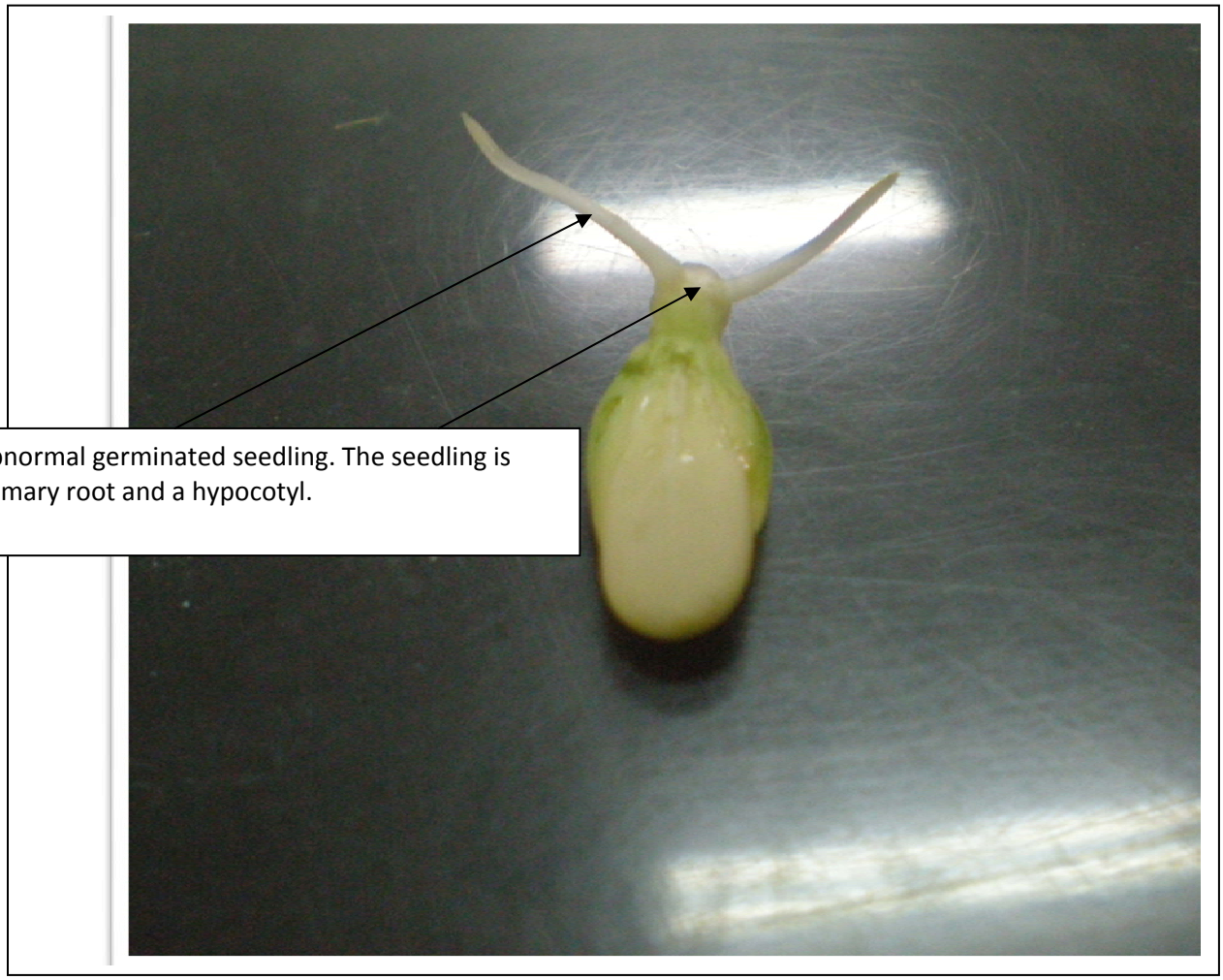
Normal Germination



This is an image of a normally germinated *Cucumis sativus* seedling. There is a developed primary root, developed secondary roots, and an extended hypocotyl.

Appendix B

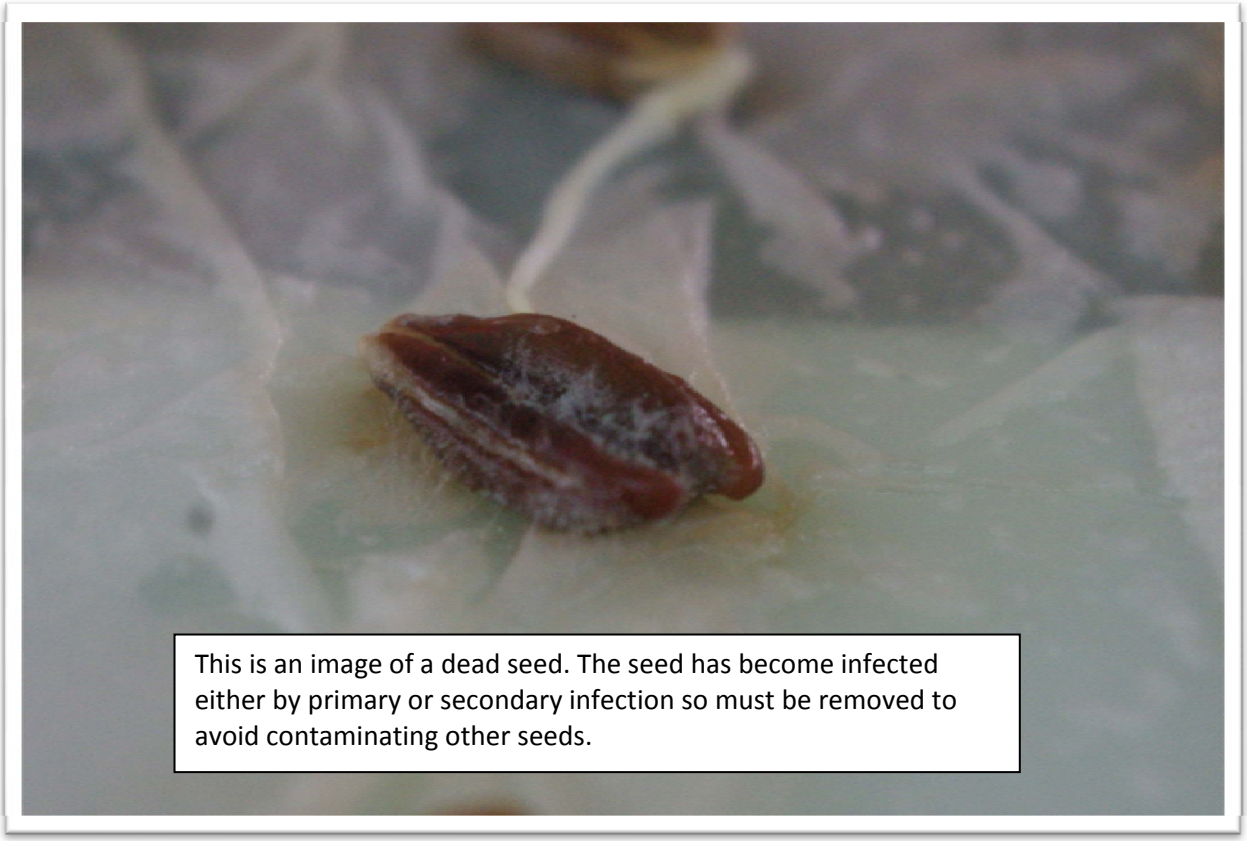
Abnormal Germination



This is an abnormal germinated seedling. The seedling is lacking a primary root and a hypocotyl.

Appendix C

Dead Germination



This is an image of a dead seed. The seed has become infected either by primary or secondary infection so must be removed to avoid contaminating other seeds.

Appendix D

Data for *Cucumis sativus*

Crop	Replication	Acc.	Storage Type	Duration	Germination Percent
Cucumis	1	1406	ST	2	84.00%
Cucumis	2	1406	ST	2	94%
Cucumis	3	1406	ST	2	78.00%
Cucumis	1	1403	ST	2	86.00%
Cucumis	2	1403	ST	2	76.00%
Cucumis	3	1403	ST	2	78.00%
Cucumis	1	1180	ST	2	76.00%
Cucumis	2	1180	ST	2	84.00%
Cucumis	3	1180	ST	2	72.00%
Cucumis	1	1406	MT	2	86.00%
Cucumis	2	1406	MT	2	82.00%
Cucumis	3	1406	MT	2	76.00%
Cucumis	1	1403	MT	2	92.00%
Cucumis	2	1403	MT	2	100%
Cucumis	3	1403	MT	2	90.00%
Cucumis	1	1180	MT	2	94.00%
Cucumis	2	1180	MT	2	80.00%
Cucumis	3	1180	MT	2	100.00%
Cucumis	1	1406	LT	2	80.00%
Cucumis	2	1406	LT	2	80.00%
Cucumis	3	1406	LT	2	88.00%
Cucumis	1	1403	LT	2	86.00%
Cucumis	2	1403	LT	2	90.00%
Cucumis	3	1403	LT	2	78.00%
Cucumis	1	1180	LT	2	76.00%
Cucumis	2	1180	LT	2	94.00%
Cucumis	3	1180	LT	2	88.00%
Cucumis	1	1406	ST	4	78.00%
Cucumis	2	1406	ST	4	76.00%
Cucumis	3	1406	ST	4	76.00%
Cucumis	1	1403	ST	4	88.00%
Cucumis	2	1403	ST	4	80.00%
Cucumis	3	1403	ST	4	80.00%
Cucumis	1	1180	ST	4	76.00%
Cucumis	2	1180	ST	4	84.00%
Cucumis	3	1180	ST	4	78.00%
Cucumis	1	1406	MT	4	90.00%
Cucumis	2	1406	MT	4	76.00%
Cucumis	3	1406	MT	4	80.00%
Cucumis	1	1403	MT	4	80.00%
Cucumis	2	1403	MT	4	80.00%
Cucumis	3	1403	MT	4	84.00%
Cucumis	1	1180	MT	4	78.00%

Cucumis	2	1180	MT	4	72.00%
Cucumis	3	1180	MT	4	84.00%
Cucumis	1	1406	LT	4	88.00%
Cucumis	2	1406	LT	4	72.00%
Cucumis	3	1406	LT	4	78.00%
Cucumis	1	1403	LT	4	72.00%
Cucumis	2	1403	LT	4	82.00%
Cucumis	3	1403	LT	4	86.00%
Cucumis	1	1180	LT	4	88.00%
Cucumis	2	1180	LT	4	70.00%
Cucumis	3	1180	LT	4	82.00%
Cucumis	1	1406	ST	8	84.00%
Cucumis	2	1406	ST	8	86.00%
Cucumis	3	1406	ST	8	92.00%
Cucumis	1	1403	ST	8	82.00%
Cucumis	2	1403	ST	8	90.00%
Cucumis	3	1403	ST	8	92.00%
Cucumis	1	1180	ST	8	100%
Cucumis	2	1180	ST	8	86.00%
Cucumis	3	1180	ST	8	92.00%
Cucumis	1	1406	MT	8	94.00%
Cucumis	2	1406	MT	8	92.00%
Cucumis	3	1406	MT	8	96.00%
Cucumis	1	1403	MT	8	94.00%
Cucumis	2	1403	MT	8	94.00%
Cucumis	3	1403	MT	8	90.00%
Cucumis	1	1180	MT	8	92.00%
Cucumis	2	1180	MT	8	90.00%
Cucumis	3	1180	MT	8	96.00%
Cucumis	1	1406	LT	8	86.00%
Cucumis	2	1406	LT	8	80.00%
Cucumis	3	1406	LT	8	96.00%
Cucumis	1	1403	LT	8	92.00%
Cucumis	2	1403	LT	8	96.00%
Cucumis	3	1403	LT	8	90.00%
Cucumis	1	1180	LT	8	96.00%
Cucumis	2	1180	LT	8	82.00%
Cucumis	3	1180	LT	8	84.00%

Appendix E

Data for *Lagenaria siceraria*

Crop	Replication	Acc.	Storage Type	Duration	Germination Percent
Lagenaria	1	7335-A	ST	2	68.00%
Lagenaria	2	7335-A	ST	2	64.00%
Lagenaria	3	7335-A	ST	2	38.00%
Lagenaria	1	7335-D	ST	2	58.00%
Lagenaria	2	7335-D	ST	2	78.00%
Lagenaria	3	7335-D	ST	2	58.00%
Lagenaria	1	7334-A	ST	2	92.00%
Lagenaria	2	7334-A	ST	2	90.00%
Lagenaria	3	7334-A	ST	2	82.00%
Lagenaria	1	7335-A	MT	2	80.00%
Lagenaria	2	7335-A	MT	2	78.00%
Lagenaria	3	7335-A	MT	2	78.00%
Lagenaria	1	7335-D	MT	2	70.00%
Lagenaria	2	7335-D	MT	2	60.00%
Lagenaria	3	7335-D	MT	2	64.00%
Lagenaria	1	7334-A	MT	2	76.00%
Lagenaria	2	7334-A	MT	2	88.00%
Lagenaria	3	7334-A	MT	2	70.00%
Lagenaria	1	7335-A	LT	2	72.00%
Lagenaria	2	7335-A	LT	2	74.00%
Lagenaria	3	7335-A	LT	2	72.00%
Lagenaria	1	7335-D	LT	2	86.00%
Lagenaria	2	7335-D	LT	2	72.00%
Lagenaria	3	7335-D	LT	2	72.00%
Lagenaria	1	7334-A	LT	2	82.00%
Lagenaria	2	7334-A	LT	2	94.00%
Lagenaria	3	7334-A	LT	2	82.00%
Lagenaria	1	7335-A	ST	4	76.00%
Lagenaria	2	7335-A	ST	4	76.00%
Lagenaria	3	7335-A	ST	4	80.00%
Lagenaria	1	7335-D	ST	4	56.00%
Lagenaria	2	7335-D	ST	4	60.00%
Lagenaria	3	7335-D	ST	4	60.00%
Lagenaria	1	7334-A	ST	4	88.00%
Lagenaria	2	7334-A	ST	4	82.00%
Lagenaria	3	7334-A	ST	4	88.00%
Lagenaria	1	7335-A	MT	4	66.00%
Lagenaria	2	7335-A	MT	4	50.00%
Lagenaria	3	7335-A	MT	4	62.00%
Lagenaria	1	7335-D	MT	4	82.00%
Lagenaria	2	7335-D	MT	4	70.00%
Lagenaria	3	7335-D	MT	4	62.00%
Lagenaria	1	7334-A	MT	4	84.00%

Lagenaria	2	7334-A	MT	4	76.00%
Lagenaria	3	7334-A	MT	4	68.00%
Lagenaria	1	7335-A	LT	4	66.00%
Lagenaria	2	7335-A	LT	4	54.00%
Lagenaria	3	7335-A	LT	4	74.00%
Lagenaria	1	7335-D	LT	4	56.00%
Lagenaria	2	7335-D	LT	4	60.00%
Lagenaria	3	7335-D	LT	4	88.00%
Lagenaria	1	7334-A	LT	4	82.00%
Lagenaria	2	7334-A	LT	4	80.00%
Lagenaria	3	7334-A	LT	4	82.00%
Lagenaria	1	7335-A	ST	8	88.00%
Lagenaria	2	7335-A	ST	8	84.00%
Lagenaria	3	7335-A	ST	8	98.00%
Lagenaria	1	7335-D	ST	8	86.00%
Lagenaria	2	7335-D	ST	8	84.00%
Lagenaria	3	7335-D	ST	8	94.00%
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Lagenaria	2	7335-A	MT	8	74.00%
Lagenaria	3	7335-A	MT	8	78.00%
Lagenaria	1	7335-D	MT	8	88.00%
Lagenaria	2	7335-D	MT	8	74.00%
Lagenaria	3	7335-D	MT	8	96.00%
Lagenaria	1	7334-A	MT	8	98.00%
Lagenaria	2	7334-A	MT	8	64.00%
Lagenaria	3	7334-A	MT	8	100.00%
Lagenaria	1	7335-A	LT	8	88.00%
Lagenaria	2	7335-A	LT	8	94.00%
Lagenaria	3	7335-A	LT	8	92.00%
Lagenaria	1	7335-D	LT	8	90.00%
Lagenaria	2	7335-D	LT	8	96.00%
Lagenaria	3	7335-D	LT	8	100.00%
Lagenaria	1	7334-A	LT	8	98.00%
Lagenaria	2	7334-A	LT	8	86.00%
Lagenaria	3	7334-A	LT	8	92.00%

Appendix F

Data for *Momordica charantia*

Crop	Replication	Acc.	Storage Type	Duration	Germination Percent
Momordica	1	7098	ST	2	60.00%
Momordica	2	7098	ST	2	76.00%
Momordica	3	7098	ST	2	12.00%
Momordica	1	6236	ST	2	36.00%
Momordica	2	6236	ST	2	40.00%
Momordica	3	6236	ST	2	52.00%
Momordica	1	6557	ST	2	56.00%
Momordica	2	6557	ST	2	24.00%
Momordica	3	6557	ST	2	40.00%
Momordica	1	7098	MT	2	32.00%
Momordica	2	7098	MT	2	12.00%
Momordica	3	7098	MT	2	52.00%
Momordica	1	6236	MT	2	28.00%
Momordica	2	6236	MT	2	60.00%
Momordica	3	6236	MT	2	36.00%
Momordica	1	6557	MT	2	40.00%
Momordica	2	6557	MT	2	20.00%
Momordica	3	6557	MT	2	24.00%
Momordica	1	7098	LT	2	0.00%
Momordica	2	7098	LT	2	0.00%
Momordica	3	7098	LT	2	0.00%
Momordica	1	6236	LT	2	0.00%
Momordica	2	6236	LT	2	8.00%
Momordica	3	6236	LT	2	0.00%
Momordica	1	6557	LT	2	0.00%
Momordica	2	6557	LT	2	0.00%
Momordica	3	6557	LT	2	0.00%
Momordica	1	7098	ST	4	72.00%
Momordica	2	7098	ST	4	48.00%
Momordica	3	7098	ST	4	60.00%
Momordica	1	6236	ST	4	32.00%
Momordica	2	6236	ST	4	24.00%
Momordica	3	6236	ST	4	48.00%
Momordica	1	6557	ST	4	0.00%
Momordica	2	6557	ST	4	40.00%
Momordica	3	6557	ST	4	56.00%
Momordica	1	7098	MT	4	24.00%
Momordica	2	7098	MT	4	44.00%
Momordica	3	7098	MT	4	32.00%
Momordica	1	6236	MT	4	24.00%
Momordica	2	6236	MT	4	52.00%
Momordica	3	6236	MT	4	40.00%
Momordica	1	6557	MT	4	16.00%

Momordica	2	6557	MT	4	28.00%
Momordica	3	6557	MT	4	36.00%
Momordica	1	7098	LT	4	0.00%
Momordica	2	7098	LT	4	0.00%
Momordica	3	7098	LT	4	0.00%
Momordica	1	6236	LT	4	0.00%
Momordica	2	6236	LT	4	0.00%
Momordica	3	6236	LT	4	4.00%
Momordica	1	6557	LT	4	0.00%
Momordica	2	6557	LT	4	0.00%
Momordica	3	6557	LT	4	0.00%
Momordica	1	7098	ST	8	92.00%
Momordica	2	7098	ST	8	68.00%
Momordica	3	7098	ST	8	88.00%
Momordica	1	6236	ST	8	48.00%
Momordica	2	6236	ST	8	36.00%
Momordica	3	6236	ST	8	60.00%
Momordica	1	6557	ST	8	40.00%
Momordica	2	6557	ST	8	48.00%
Momordica	3	6557	ST	8	48.00%
Momordica	1	7098	MT	8	56.00%
Momordica	2	7098	MT	8	36.00%
Momordica	3	7098	MT	8	32.00%
Momordica	1	6236	MT	8	68.00%
Momordica	2	6236	MT	8	64.00%
Momordica	3	6236	MT	8	48.00%
Momordica	1	6557	MT	8	24.00%
Momordica	2	6557	MT	8	12.00%
Momordica	3	6557	MT	8	16.00%
Momordica	1	7098	LT	8	0.00%
Momordica	2	7098	LT	8	0.00%
Momordica	3	7098	LT	8	0.00%
Momordica	1	6236	LT	8	0.00%
Momordica	2	6236	LT	8	20.00%
Momordica	3	6236	LT	8	12.00%
Momordica	1	6557	LT	8	0.00%
Momordica	2	6557	LT	8	0.00%
Momordica	3	6557	LT	8	0.00%

Appendix G

Data for *Cucurbita moschata*

Crop	Replication	Acc.	Storage Type	Duration	Germination Percent
Cucurbita	1	6252	ST	2	72.00%
Cucurbita	2	6252	ST	2	72.00%
Cucurbita	3	6252	ST	2	92.00%
Cucurbita	1	7875	ST	2	88.00%
Cucurbita	2	7875	ST	2	76.00%
Cucurbita	3	7875	ST	2	92.00%
Cucurbita	1	1185	ST	2	76.00%
Cucurbita	2	1185	ST	2	92.00%
Cucurbita	3	1185	ST	2	84.00%
Cucurbita	1	6252	MT	2	64.00%
Cucurbita	2	6252	MT	2	64.00%
Cucurbita	3	6252	MT	2	88.00%
Cucurbita	1	7875	MT	2	84.00%
Cucurbita	2	7875	MT	2	72.00%
Cucurbita	3	7875	MT	2	96.00%
Cucurbita	1	1185	MT	2	100.00%
Cucurbita	2	1185	MT	2	92.00%
Cucurbita	3	1185	MT	2	92.00%
Cucurbita	1	6252	LT	2	88.00%
Cucurbita	2	6252	LT	2	64.00%
Cucurbita	3	6252	LT	2	76.00%
Cucurbita	1	7875	LT	2	88.00%
Cucurbita	2	7875	LT	2	76.00%
Cucurbita	3	7875	LT	2	92.00%
Cucurbita	1	1185	LT	2	96.00%
Cucurbita	2	1185	LT	2	88.00%
Cucurbita	3	1185	LT	2	100.00%
Cucurbita	1	6252	ST	4	72.00%
Cucurbita	2	6252	ST	4	92.00%
Cucurbita	3	6252	ST	4	72.00%
Cucurbita	1	7875	ST	4	100.00%
Cucurbita	2	7875	ST	4	76.00%
Cucurbita	3	7875	ST	4	96.00%
Cucurbita	1	1185	ST	4	96.00%
Cucurbita	2	1185	ST	4	92.00%
Cucurbita	3	1185	ST	4	100.00%
Cucurbita	1	6252	MT	4	56.00%
Cucurbita	2	6252	MT	4	76.00%
Cucurbita	3	6252	MT	4	92.00%
Cucurbita	1	7875	MT	4	84.00%
Cucurbita	2	7875	MT	4	96.00%
Cucurbita	3	7875	MT	4	96.00%
Cucurbita	1	1185	MT	4	88.00%

Cucurbita	2	1185	MT	4	92.00%
Cucurbita	3	1185	MT	4	96.00%
Cucurbita	1	6252	LT	4	84.00%
Cucurbita	2	6252	LT	4	84.00%
Cucurbita	3	6252	LT	4	80.00%
Cucurbita	1	7875	LT	4	100.00%
Cucurbita	2	7875	LT	4	80.00%
Cucurbita	3	7875	LT	4	88.00%
Cucurbita	1	1185	LT	4	96.00%
Cucurbita	2	1185	LT	4	92.00%
Cucurbita	3	1185	LT	4	100.00%
Cucurbita	1	6252	ST	8	68.00%
Cucurbita	2	6252	ST	8	76.00%
Cucurbita	3	6252	ST	8	72.00%
Cucurbita	1	7875	ST	8	92.00%
Cucurbita	2	7875	ST	8	88.00%
Cucurbita	3	7875	ST	8	92.00%
Cucurbita	1	1185	ST	8	88.00%
Cucurbita	2	1185	ST	8	92.00%
Cucurbita	3	1185	ST	8	92.00%
Cucurbita	1	6252	MT	8	72.00%
Cucurbita	2	6252	MT	8	68.00%
Cucurbita	3	6252	MT	8	72.00%
Cucurbita	1	7875	MT	8	96.00%
Cucurbita	2	7875	MT	8	100.00%
Cucurbita	3	7875	MT	8	92.00%
Cucurbita	1	1185	MT	8	92.00%
Cucurbita	2	1185	MT	8	96.00%
Cucurbita	3	1185	MT	8	84.00%
Cucurbita	1	6252	LT	8	84.00%
Cucurbita	2	6252	LT	8	84.00%
Cucurbita	3	6252	LT	8	64.00%
Cucurbita	1	7875	LT	8	96.00%
Cucurbita	2	7875	LT	8	72.00%
Cucurbita	3	7875	LT	8	92.00%
Cucurbita	1	1185	LT	8	100.00%
Cucurbita	2	1185	LT	8	96.00%
Cucurbita	3	1185	LT	8	88.00%